TVET CERTIFICATE III IN AUTOMOBILE ENGINE TECHNOLOGY

AUTOMOTIVE ENGINE FUEL SUPPLY SYSTEM REPAIRING

AUTFS301

Repair automotive engine fuel supply system

Competence

REQF Level: 3

Learning Hours: 40

Credits: 4

Sector: Transport and logistics

Sub-sector: Automobile

Module Note Issue date: November, 2020

Purpose statement

This particular module describes the performance outcomes, skills, attitude and knowledge required to repair fuel supply system of motor vehicle. It is very core to every mechanic to demonstrate the understanding of the operation of fuel supply system, to disassemble, test, check and assemble the fuel supply components in order to keep fuel supply system in good condition.

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Learning Unit 1 – Identify fuel supply system

Introduction

The fuel supply system is intended to supply the engine's mixture-formation system with sufficient fuel in all operating states. The fuel stored in the fuel tank and then delivered both to the cylinders. Petrol engine use light grade gasoline fuel while the Diesel Engines utilize heavy diesel fuel, therefore fuel supply systems and them differ greatly in petrol and diesel engine, fuel tank stores fuel and Fuel Pump is used to supply petrol from the petrol tank through the fuel filter to the Carburettor or common rails or high pressure injection pump, fuel is transported through fuel line. Therefore the fuel is injected by fuel injectors to the combustion chamber.

LO 1.1 – Identify types of fuel system

- ✓ Content/Topic 1 identification of fuel according to the types of engines

The fuel-supply system is intended to supply the engine's mixture-formation system with sufficient fuel in all operating states.

Definition of terms

i. Fuel:

Materials such as coal, gas, or oil that is burned to produce heat or power

ii. Volatility:

It is a property of gasoline that facilitate measurement of how easily a liquid (fuel) vaporizes

iii. Air-fuel ratio:

It is the right amounts of air and fuel that must be mixed together for proper combustion and engine performance.

iv. Learn mixture:

It is a mixture that contains a large amount of air for the available fuel

Ex: 16:1

v. Rich mixture:

A rich air-fuel mixture: It contains a little more (too much) fuel mixed with the available air.

Ex: 14:1

vi. Mixture ratio:

The mixture ratio describes the composition of the fuel-air mixture. There are two different types of mixture ratio: the theoretical and the practical.

vii. Theoretical mixture ratio (stoichiometric ratio = theoretical air requirement):

This specifies how many kg of air are required for the complete combustion of 1 kg of fuel. To burn 1 kg of petrol, this figure is roughly 14.8 kg or 10,300 l of air.

viii. Practical mixture ratio:

This deviates from the theoretical mixture ratio, depending on the engine operating state. A mixture with a larger proportion of fuel, e.g. 1:13, is known as a "rich" mixture (air deficiency). A mixture with a smaller proportion of fuel, e.g. 1:16, is known as a "lean" mixture (excess air).

Mixture composition

Homogeneous mixture:

The mixture composition is the same in the entire combustion chamber. In order to achieve a homogeneous mixture composition, sufficient time must be made available for a uniform and thorough mixing of the fuel-air mixture. This is achieved by an advanced injection point during induction or by injection of fuel into the intake manifold.

Heterogeneous mixture:

The combustion chamber has areas of differing mixture composition (stratified charge). A retarded injection of fuel into the cylinder during the compression stroke and precisely matched air turbulence facilitate a non-uniform mixture composition. There must be an air ratio of X approximately equal to 1 to ensure safe ignition of the mixture in the spark-plug area in spark-ignition engines. The mixture is lean in the marginal areas of the combustion chamber

ix. Part load:

The engine does not provide power to the flywheel at idle. Part-load (or part-throttle) operation refers to the range of running conditions between idle and generation of maximum possible torque.

x. Full load:

When the throttle valve has opened to its maximum, the engine should respond by providing its maximum torque/output.

xi. Idle speed:

it is a rotational speed of an engine at when the accelerator pedal is not depressed and drive train is disconnected from the engine.

xii. Cold start:

An attempt to start an engine when is cold.

There are two types of fuel supply in spark ignition engine

- Carburettor
- Petrol injection

1. **Carburator**

The carburettor is intended to atomise the fuel and mix it with air in the correct proportion. It must adapt the required amount of mixture to the respective engine operating state.

Carburetors usually consist of three main components: throttle-valve assembly, carburetor housing and carburettor cover.

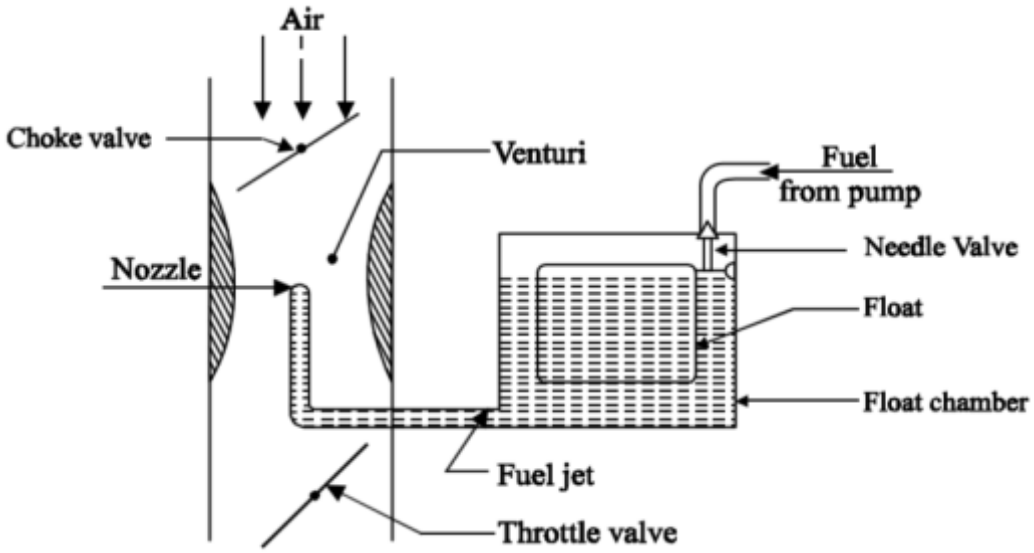

Figure 1 carburetor fuel supply circuit diagram

The main functions of the carburettor are:

(I) To mix the air and fuel thoroughly
(ii) To atomize the fuel
(iii) To regulate the air-fuel ratio at different speeds and loads
(iv) To supply correct amount of mixture at different speeds and loads.
(v) Measure the airflow of the engine
(vi) Deliver the correct amount of fuel to keep the fuel/air mixture in the proper range
(vii) Mix the two finely and evenly

2. **Petrol injection**

Petrol injection system is to spray fuel in finely atomised state into the inducted air. The required mixture quantity in each case and the mixture ratio must be adapted to the respective operating state in the process.

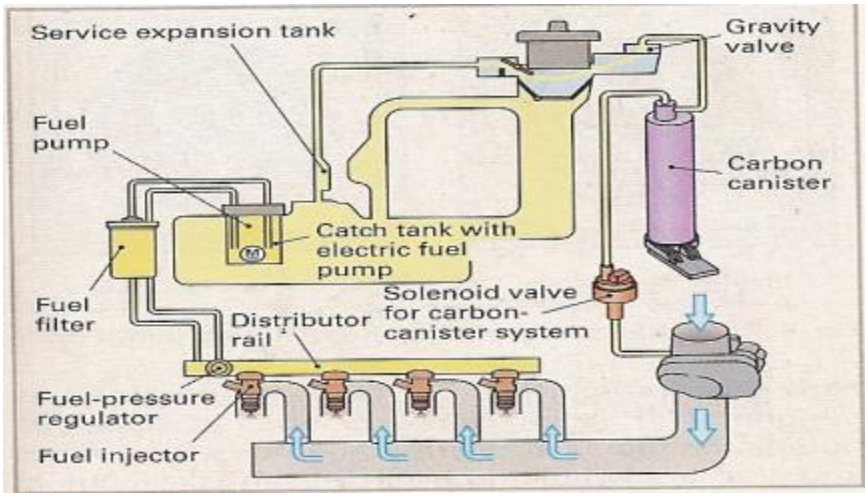

Figure 2 petrol injection fuel supply diagram

Petrol fuel injection systems the fuel is sprayed into the air in finely atomised state with the aid of nozzles and the pressure built up by the fuel pump. This increases the surface area of the injected fuel. This causes the fuel to carbonate more quickly, which in turn leads to improved mixing with air, more complete combustion and better exhaust-gas values.

In the case of indirect injection (exterior mixture formation), the fuel injectors are arranged in such a way as to inject into the intake manifold or into the throttle-valve housing. In the case of direct injection (interior mixture formation), the fuel injectors are arranged in such a way as to inject into the combustion chamber.

The following objectives should be achieved:

- ✓ High engine torque High engine power
- ✓ Favourable engine performance curves
- ✓ Low fuel consumption
- ✓ Favourable exhaust-gas values

Petrol injection can be direct or indirect injection to the combustion chamber

Direct Injection

- ✓ The fuel is injected directly into an open combustion chamber formed by the piston and cylinder head.
- ✓ The main advantage of this type of injection is that it is simple and has high fuel efficiency.
- ✓ Fuel and air start to be mixed inside of the combustion chamber (interior mixture)

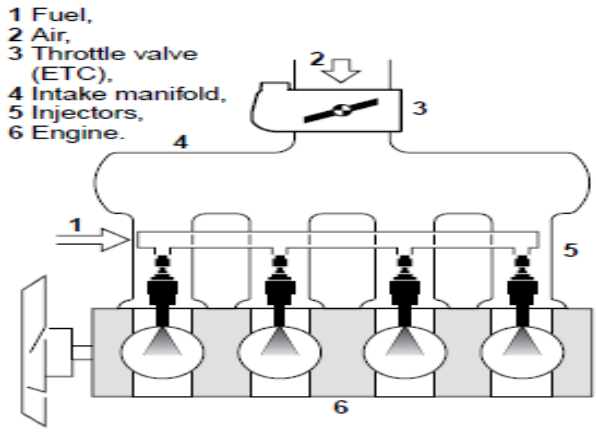

Figure 3 direct injection

Indirect Injection

- ✓ The fuel is injected into the intake manifold or throttle valve housing. Fuel and air already start to be mixed outside the combustion chamber (exterior mixture)

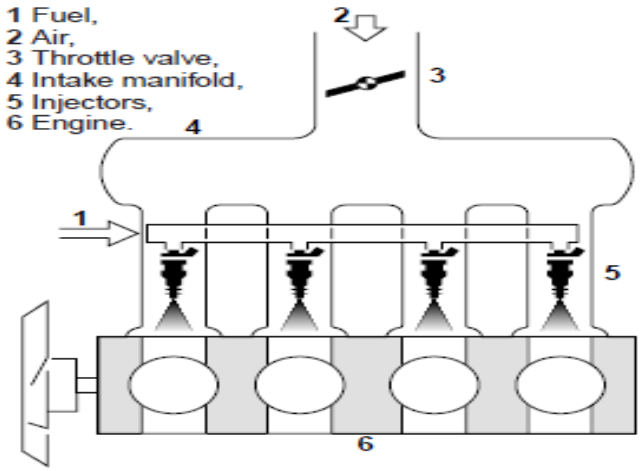

Figure 4 indirect injection

✓ Content/Topic 2 identification of the types of fuel supply for diesel engine

Vehicle injection systems perform the following tasks:

- ✓ Provide the necessary injection pressure available.
- ✓ Inject the necessary quantity of fuel (fuel delivery control).
- ✓ Adjust the required start of injection (start of injection control)

There are basically two different injection processes used in diesel engines:

- Direct injection into an undivided combustion: chamber (DI)

• Indirect injection into the secondary chamber of a divided combustion chamber (IDI)

Indirect-injection diesel engines: Two different processes may be used, based on the shape of the secondary chamber: pre-chamber and whirl-chamber process.

A difference is made between the following fuel injection system types diagrams:

✓ **Distributor Rotary injection pump**

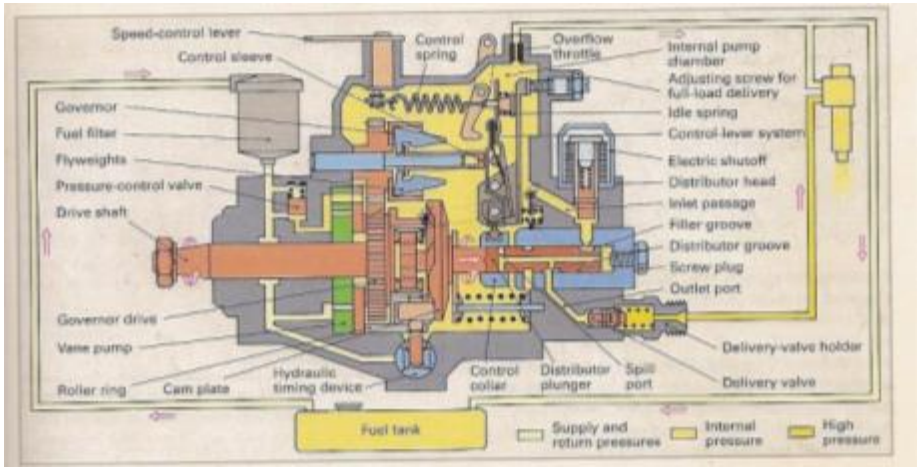

Figure 6 distributor rotary injection pump

- **Inline injection pump**

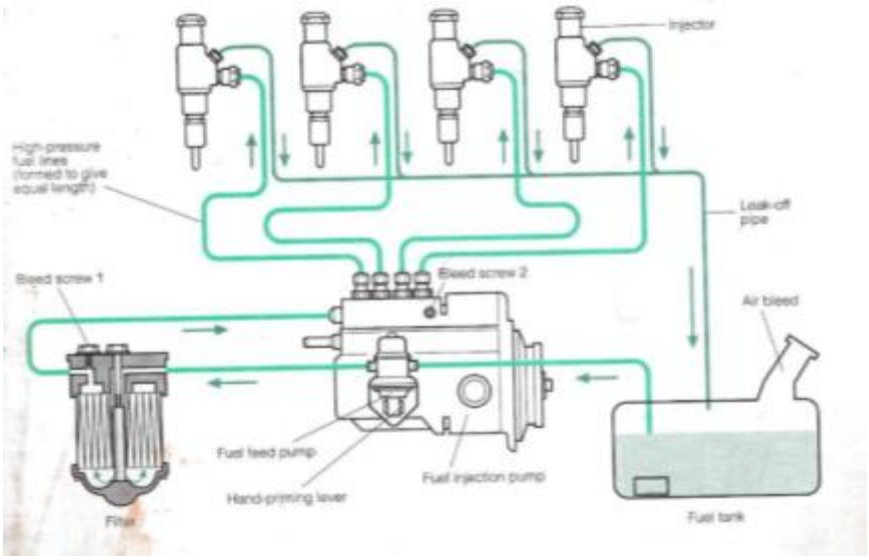

Figure 7 inline injection pump

- ✓ **Common rail system**

In a common-rail system the fuel is accumulated in a fuel rail under high pressure and injected into the combustion chambers under map- controlled conditions via solenoid valves on the injectors.

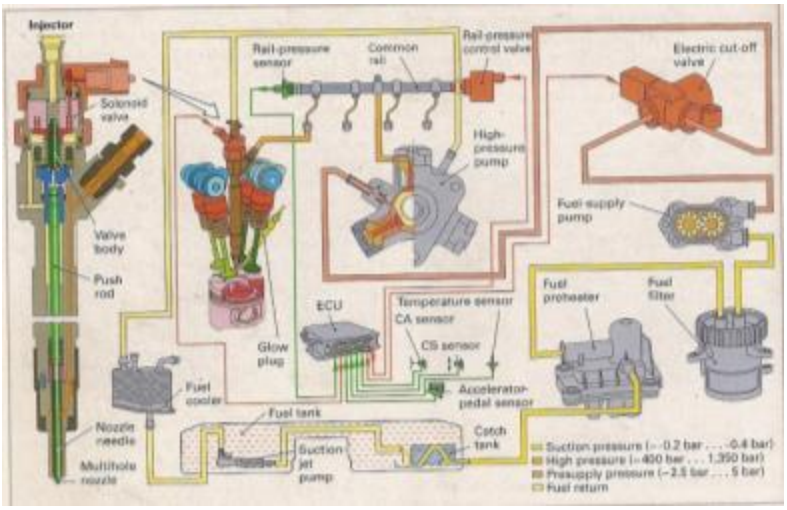

Figure 8 common rail system

The fuel-injection equipment comprises:

Low-pressure circuit:

This is divided into the suction pressure area, the pre-supply pressure area and the fuel return. It contains the fuel tank, fuel preheater, fuel filter, fuel-supply pump, electric cut-off valve and fuel cooler.

High-pressure area:

This consists of the high pressure pump, the high-pressure lines, the rail and one injector for each cylinder.

Electronic control system:

This comprises the ECU, the sensor equipment, the rail-pressure control valve, the injector solenoid valves and the cut-off valve.

LO 1.2 – Describe petrol fuel supply

✓ Content/Topic 1 introduction of petrol fuel supply

The fuel-supply system is intended to supply the engine's mixture-formation system with sufficient fuel in all operating states

Purpose of petrol fuel supply system

- ✓ Store fuel in the fuel tank
- ✓ Deliver bubble free fuel
- ✓ Filter fuel
- ✓ Generate fuel pressure and keep it constant
- ✓ Return excess fuel
- ✓ Prevent fuel vapours from escaping

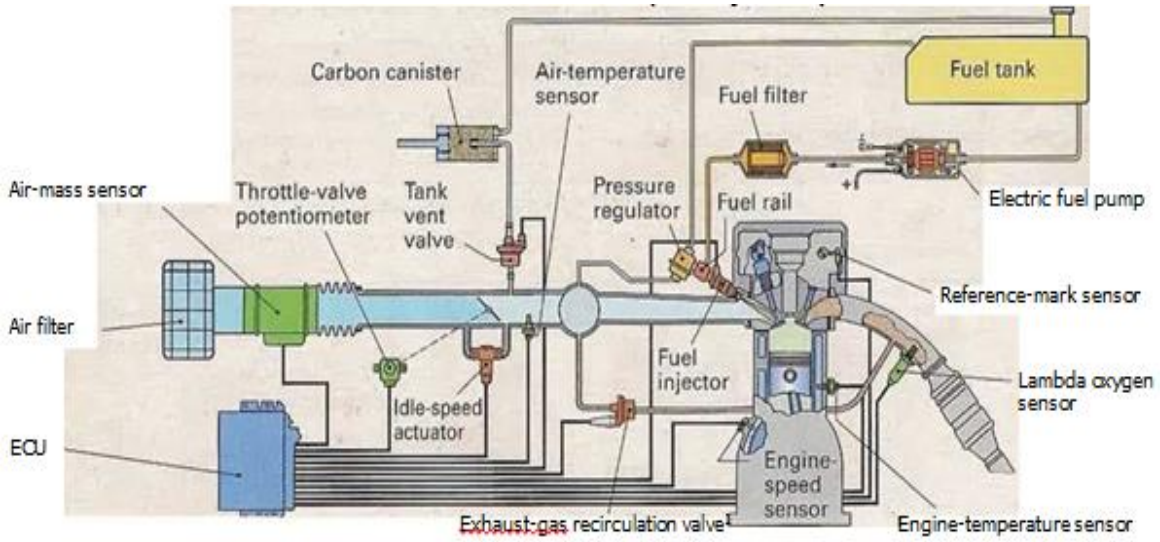

Figure 9 petrol fuel suppy system

✓ Content/Topic 2 Description of petrol fuel supply components

Description of petrol fuel supply components:

1. **Fuel tank**

Store fuel for future use, Sheet-steel fuel tanks, on account of their simple structural shape and associated problem-free man-ufacture, are usually used in commercial vehicles.

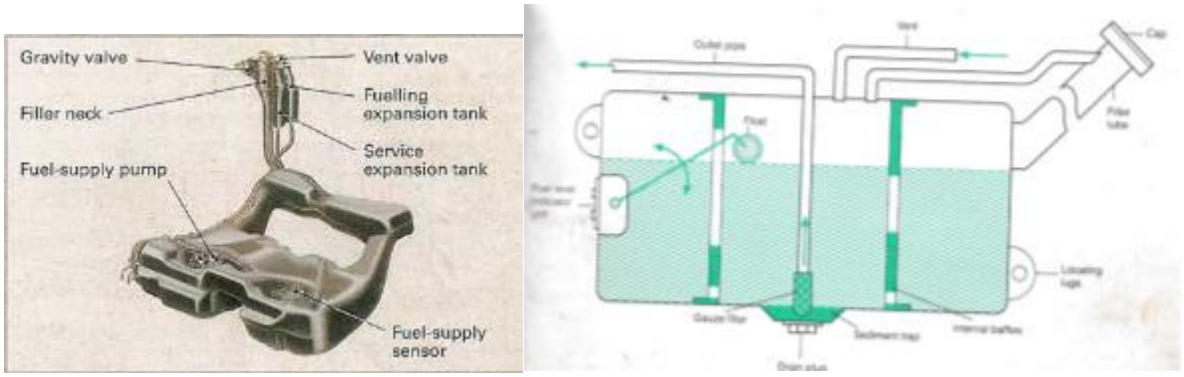

Figure 10 fuel tank

Tank location and design are always a compromise with available space. Most automobiles have a single tank located in the rear of the vehicle. Fuel tanks today have internal baffles to prevent the fuel from sloshing back and forth. If you hear noises from the rear on acceleration and deceleration the baffles could be broken. All tanks have a fuel filler pipe, a fuel outlet line to the engine and a vent system.

2. Delivery pump/ electrical pump

It draws the fuel from the tank and delivers fuel to the engine's injection system or to the carburettor. Two different types are used, depending on their installation locations: inline pumps and in-tank pumps

Two types of fuel pumps are used in automobiles:

- ✓ **Mechanical**
- ✓ **Electric fuel pumps**.

All fuel injected cars today use electric fuel pumps, while most carburetted cars use mechanical fuel pumps.

Mechanical

Mechanical fuel pumps are diaphragm pumps, mounted on the engine and operated by an eccentric cam usually on the camshaft. A rocker arm attached to the eccentric moves up and down flexing the diaphragm and pumping the fuel to the engine.

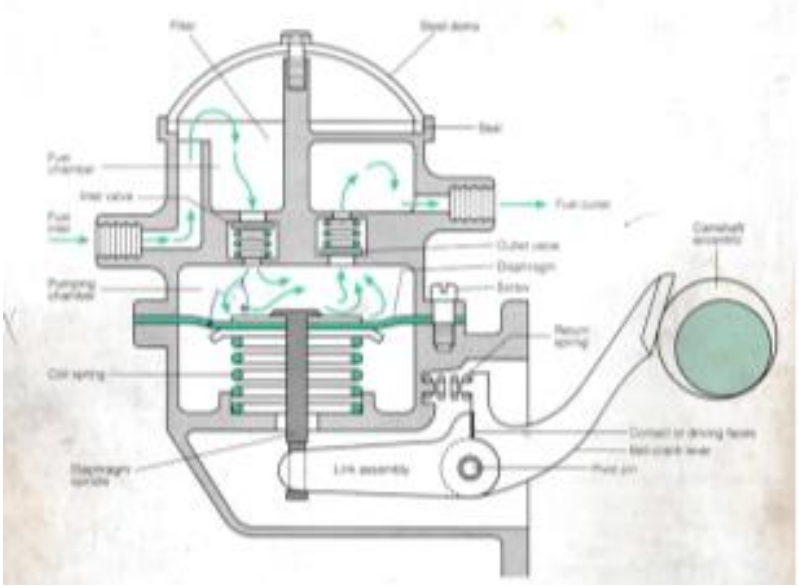

Figure 11 Mechanical fuel pump

Electric fuel pumps

Because electric pumps do not depend on an eccentric for operation, they can be located anywhere on the vehicle. In fact, they work best when located near the fuel tank.

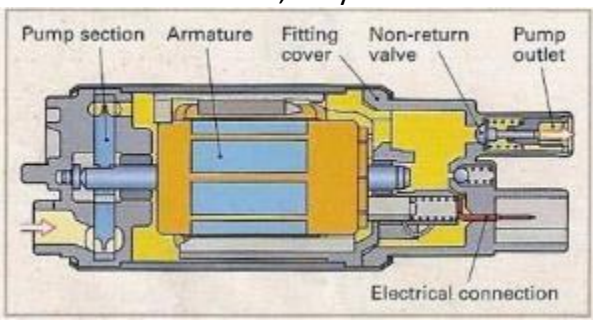

Figure 12 electrical fuel pumps

3. **Fuel filter**

   These are intended to protect the fuel system against contaminants because, for example, the fuel injectors of a petrol injection system can be destroyed even by tiny dirt particles. The fuel filter retains particles of impurities which are present in the fuel and which would otherwise have an adverse effect on the functioning of the fuel supply system.

4. **Fuel lines**
   Steel pipes or hoses made from flame-retardant, fuel-resistant rubber or plastic are used as fuel lines. Because rubber and plastic hoses change chemically (age) when used for long periods, they become hard and porous. This may result in leaks
5. **Injector**

   It has to meter and atomizes fuel so it can be sprayed into the intake manifold (**indirect injection**) or directly in the cylinder (**direct injection**).

6. **Accumulator**
   It maintains the pressure in the fuel system for a certain time after the engine has been switched off in order to facilitate restarting, particularly when the engine is hot.
7. **Pressure regulator**

The fuel pressure regulator must keep the fuel differential pressure in the two-line system constant under all conditions. it maintain the pressure differential between fuel system and intake manifold at a constant level.

8. **Rail**
   Store fuel under pressure and supply fuel whenever pump does not operate.
9. **Sensors**

Sensors record and transmit information in the form of electrical voltage signals to the ECU.

Eg: temperature sensor

10. **Actuators**

The relevant actuators, e.g. the fuel injectors, are supplied with power by the ECU. The desired system operating state is established.

11. ECU

The ECU processes the information contained in the voltage signals and compares the determined actual values with set point values usually stored in program maps. It calculates the actuation of the corresponding actuators.

- **Content/Topic 3 Description the types of fuel supply system(Carburettor system)**

a) Carburettor:

The carburettor is intended to atomise the fuel and mix it with air in the correct proportion. It must adapt the required amount of mixture to the respective engine operating state.

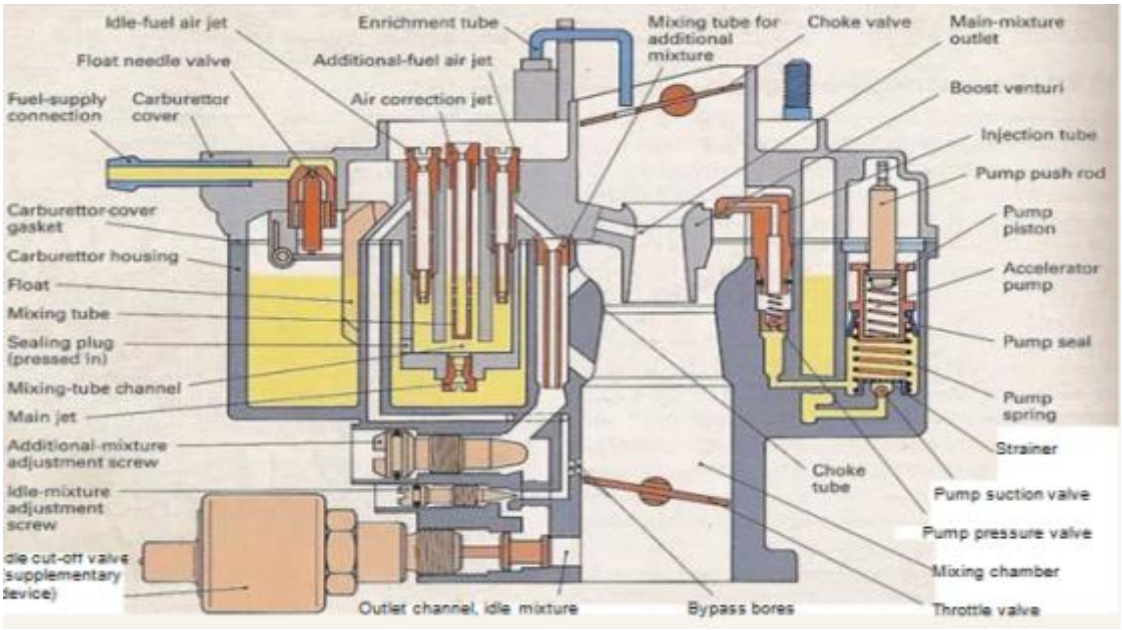

Figure 12 carburator system

Float device

The float device consists of the float housing, float and float needle valve. It is intended to regulate the fuel supply to the float chamber and keep the fuel level in the carburettor constant in all **operating states:**

Starting device

This is intended to induce a very rich fuel-air mixture of up to A « 0.2 to be formed in the carburettor during cold-starting. This ensures that an ignitable mixture of approx. A = 0.9 is available in the combustion chamber.

Idle device

This is intended to deliver the correct idle fuel-air mixture, ensure the correct idle speed and safeguard the transition from the idle system to the main-jet system.

Transition device

The idle mixture is briefly leaned when the throttle valve is opened. Additional fuel is therefore added to the ain. This is intended to ensure a sound transition from the idle system to the main-injector system and good running performance in the lower part-load range.

Main-jet system

This consists of the main jet, air correction jet and mixing tube. It is intended to draw in and atomise fuel, mix it with air and supply the correct mixture ratio in the entire part-load range.

Supplementary devices

Supplementary devices can be used in mixture preparation in order to have a beneficial effect on drive comfort and fuel consumption.

Acceleration device

When the throttle valve is opened suddenly, leaning of the mixture must be prevented and additional fuel must be made available.

Enrichment device

This is intended to bring about the enrichment of the lean part-load mixture at full load and/or part load in order to obtain the greatest possible engine power.

Operating principle

The air flow is drawn into the carburettor by the engine piston during the induction stroke. The velocity of the air flow is increased by narrowing the cross-section of the streamlined choke tube (venturi tube).The highest flow velocity and the greatest vacuum (suction) occurs at the narrowest point, which is why the fuel outlet tube is located at this point. The fuel is carried by the air flow, atomised and mixed with the air flow in the mixing- chamber area. Fine atomisation is achieved by foaming the fuel with a supply of air through the air jet below the fuel level into 3 fuel-air mixture (preliminary mixture).The throttle valve serves to control the fuel-air mixture quantity (quantity control) and with it the engine power and speed.

Carburettor types

Single-barrel carburettor

- ✓ Single-barrel carburettor

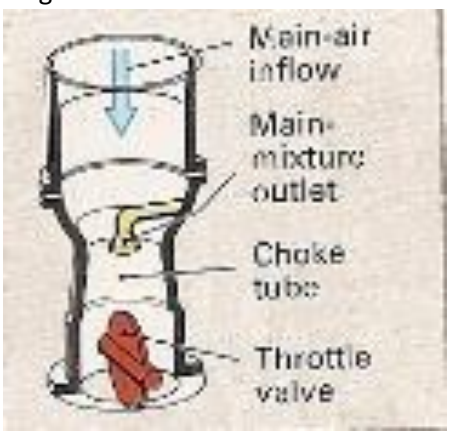

Figure 13 single barrel carburetor

- ✓ **two-stage carburettors**

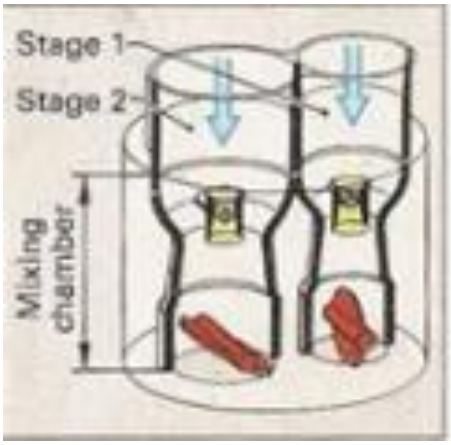

Figure 14 two stage carburettor

✓ Content/Topic 4 Description of petrol injection SPI (single point injection)

Petrol injection

The function of petrol-injection systems is to spray fuel in finely atomised state into the inducted air. The required mixture quantity in each case and the mixture ratio must be adapted to the respective operating state in the process.

Types of injection

Indirect injection

With this type of injection, fuel and air already start to be mixed outside the combustion chamber. A uniformly distributed, homogeneous fuel-air mixture should be created in the whole combustion chamber during the induction and compression strokes.

The following different types of injection are used:

- ✓ Single-point injection (SPI) and
- ✓ Multipoint injection (MPI)

✓ **Single point injection fuel supply system(SPI)**

Here the fuel is injected centrally into the throttle-valve housing before the throttle valve. Atomisation in the throttle- valve gap and evaporation on hot intake-manifold walls or additional heater elements improve the preparation of the fuel-air mixture. Routes and manifolds of different lengths cause the fuel not to be distributed uniformly to all the cylinders. Peripheral turbulence and wall-applied film moistening especially in cold engines result in unequal mixture compositions. The have a negative effect on mixture formation. Single-point injection systems are much simpler in design than their multipoint counterparts.

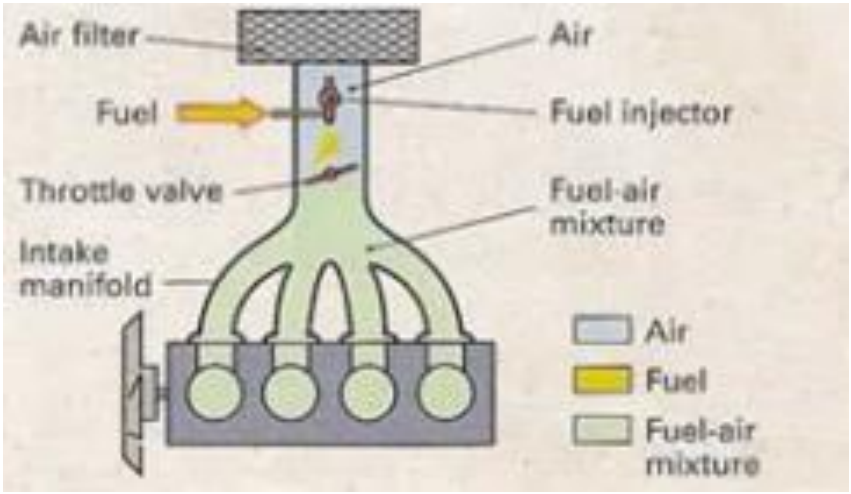

Figure 15 single point injection

In the case of single-point injection all the cylinders of an engine are supplied with fuel by a centrally situated fuel injector.

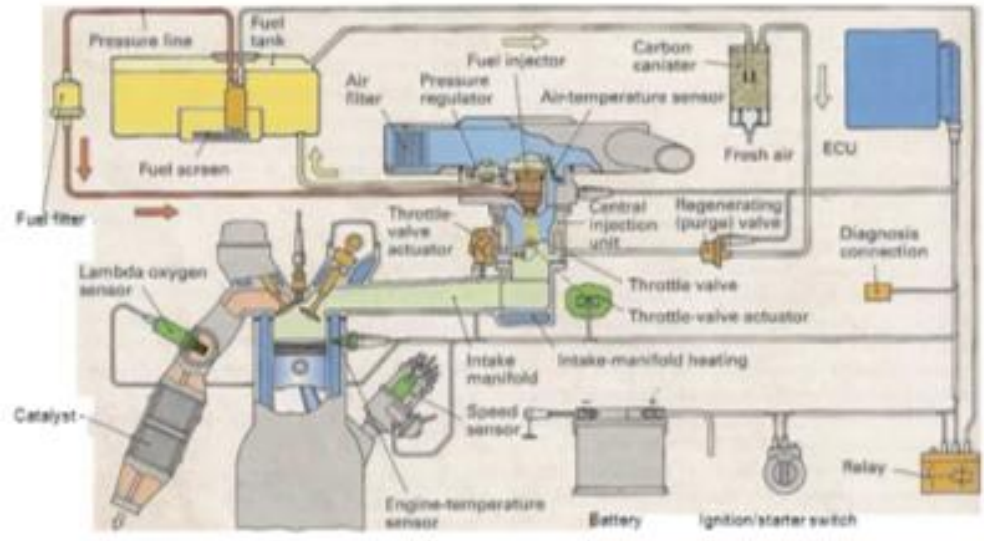

Figure 16 single point injection fuel supply system

Single-point injection systems are electronically controlled petrol-injection systems with a single electromagnetically actuated fuel injector (SPI = Single-Point Injection). The injector is opened by the ECU for each power cycle in line with the number of cylinders in the engine. (indirect injection, Single-point injection). The fuel is injected before the throttle valve.

Single-point injection subsystems

Air-intake system:

The air inducted and filtered in the air filter flows through the central injection unit. There, the temperature of the air is recorded by the intake-air sensor, which transmits it in the form of an electrical voltage to the ECU. The throttle-valve actuator, also located in the central injection unit, regulates the required air flow rate at idle in such a way that a stored set point idle speed can be maintained. Fuel is injected before the throttle valve into the inducted air (exterior mixture formation).The mixture regulated in terms of quantity by the throttle valve flows through the intake manifold on ac-count of the vacuum pressure acting in the cylinders. The intake-manifold walls or the inducted mixture are heated in order to counteract excessive condensate formation on the intake-manifold walls in cold engines. Finally, it passes through the opened inlet valves into the cylinder.

Fuel system:

An electric fuel pump delivers the fuel from the fuel tank via a fuel filter to the central injection unit. The pressure regulator installed there in the return keeps the fuel pressure constant at approximately 1 bar (low-pressure system). When the electromagnetic fuel injector is supplied with power, fuel is injected before the throttle valve into the inducted air.

Regenerating system:

The hydrocarbons temporarily stored in the carbon canister must be supplied for combustion in an appropriate operating state, e.g. part load. For this purpose, the regenerating valve is clocked by the engine ECU so that air and hydrocarbons can be drawn in by the vacuum pres¬sure acting in the intake manifold.

Operating-data acquisition

The main information on the engine operating state is provided by throttle-valve angle (a) and engine speed (n) (main controlled variables, a-n-system). From them the basic injection quantity (quantity) and thus the basic injection time can be calculated in the ECU. In order to determine the precise fuel quantity (quality), the ECU must receive further information, e.g. air temperature, and engine temperature and mixture composition, from the lambda sensor.

Single-point injection components

Central injection unit

This comprises: Hydraulic section with fuel supply, return, fuel injector, pressure regulator, air-temperature sensor Throttle-valve section with throttle valve, throttle-valve potentiometer, throttle-valve actuator

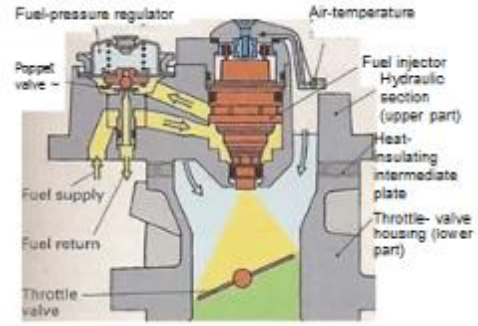

Figure 17 central injection unit

Fuel-pressure regulator

This keeps the system pressure in the return constant at 1 bar. The injected fuel quantity is therefore dependent on the injector opening time. If the fuel-pump pressure exceeds the system pressure, the spring- loaded poppet valve opens and releases the fuel return. The fuel flowing to the pressure regulator flows through and around the fuel injector beforehand for cooling. This ensures a good hot-start response.

Throttle-valve actuator

This is used for idle- speed control to a low speed level and stabilises the idle speed, for example, even when the air-conditioning system is switched on. The ECU supplies me actuating signal for positioning the throttle valve to the DC motor as a function of engine speed and engine temperature. The actuating push rod, which acts on the throttle valve, is extended and retracted by way of a screw thread.

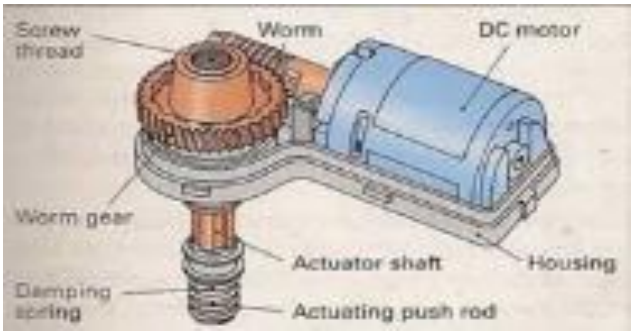

Figure 18 throttle valve actuator

Central fuel injector

This consists of the valve housing and the valve group. The valve housing accommodates the field winding with the electrical connection. The valve group consists of the valve body and the valve needle with solenoid armature guided in the body. The helical spring presses the valve needle into its seal seat with the assistance of the system pressure. When the field winding is excited, the pintle valve lifts off its seal seat by roughly 0.06 mm so that fuel can emerge from the annular orifice. The shape of the pintle nozzle provides for good atomisation together with a tapered injection jet. The fuel injector is triggered in time with the ignition pulses.

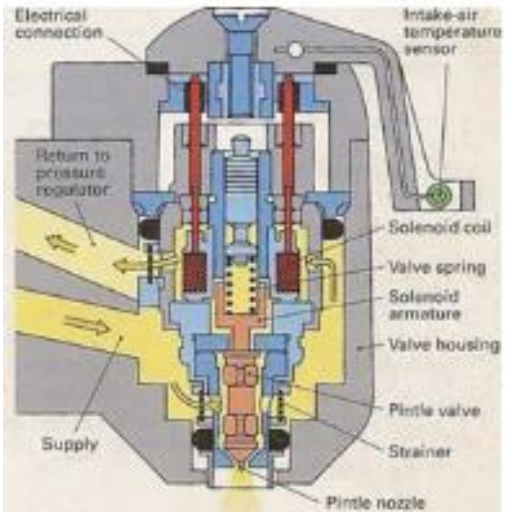

Figure 18 central fuel injector

Electronic control unit for single point injection system

The single-point injection system is electronically controlled in accordance with the IPO concept, i.e. the different operating states are recorded by sensors and transmitted to the ECU in the form of electrical signals. The ECU calculates the required starting values with the aid of various stored program maps and actuates the corresponding actuators by means of electrical signals.

The single-point injection ECU thus demonstrates the following functions: starting, warm-up, acceleration and full-load enrichment, overrun fuel cutoff, lambda closed-loop control, hot-starting control, engine-speed limitation, adaptive idle-speed control, fuel-pump-relay activation, regenerating-valve activation, limp-home-mode function, self- diagnosis

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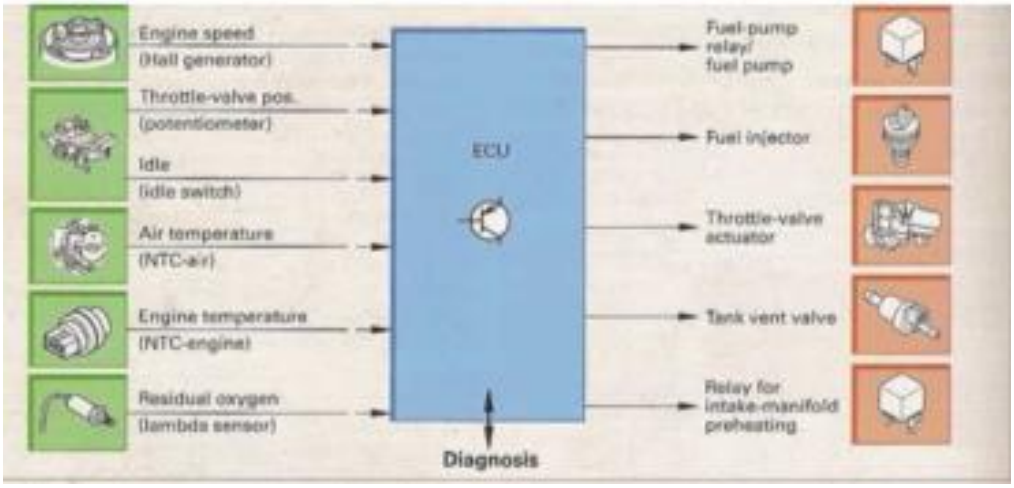


Figure 19 ECU ,sensor and actuator

The single-point injection ECU thus demonstrates the following functions:

- ✓ starting, warm-up,
- ✓ acceleration and full-load enrichment,
- ✓ overrun fuel cutoff,
- ✓ lambda closed-loop control,
- ✓ hot-starting control,
- ✓ engine-speed limitation,
- ✓ adaptive idle-speed control,
- ✓ fuel-pump-relay activation,
- ✓ regenerating- valve activation,
- ✓ limp-home-mode function,
- ✓ Self- diagnosis.

✓ Content /Topic5 Description of multipoint injection

✓ Multi point injection fuel supply system

Each cylinder is assigned a fuel injector. These injectors are situated in the intake manifold usually directly before the inlet valves. The mixture is therefore subject to intake paths of equal length and uniform distribution. An arrangement close to the inlet valves reduces the formation of wall-applied film when the engine is cold and reduces the build-up of noxious exhaust gases.

Injection can be in two types

Indirect injection

With this type of injection, fuel and air already start to be mixed outside the combustion chamber. A uniformly distributed, homogeneous fuel-air mixture should be created in the whole combustion chamber during the induction and compression strokes.

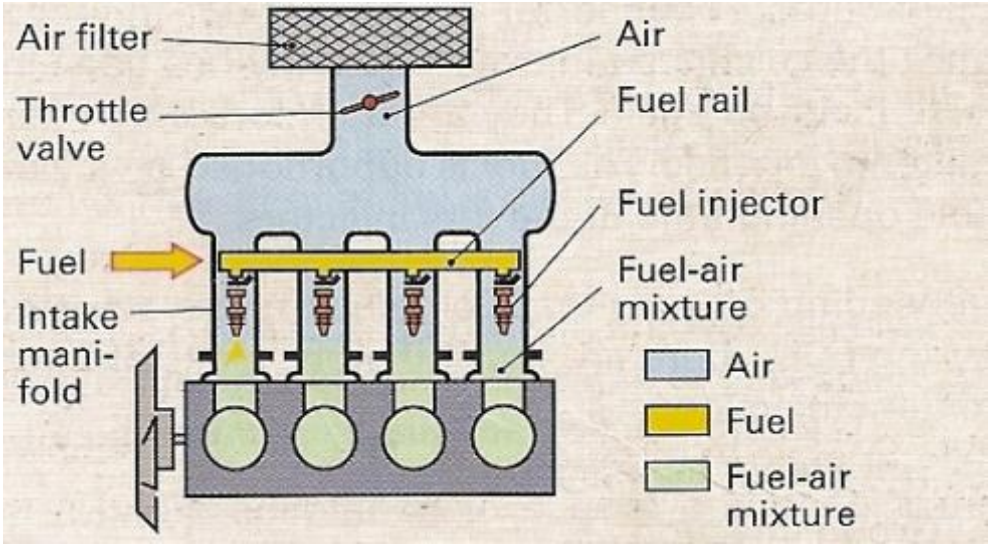


Figure 20 multi point injection sytem-indirect injection

Direct injection

Systems with direct injection are always multipoint systems. The fuel is sprayed by the electrically actuated nozzles under high pressure (up to 120 bar) directly into the combustion chamber (interior mixture formation). There, depending on the engine layout and on the operating state, a homogeneous or heterogeneous mixture is formed with the inducted air.

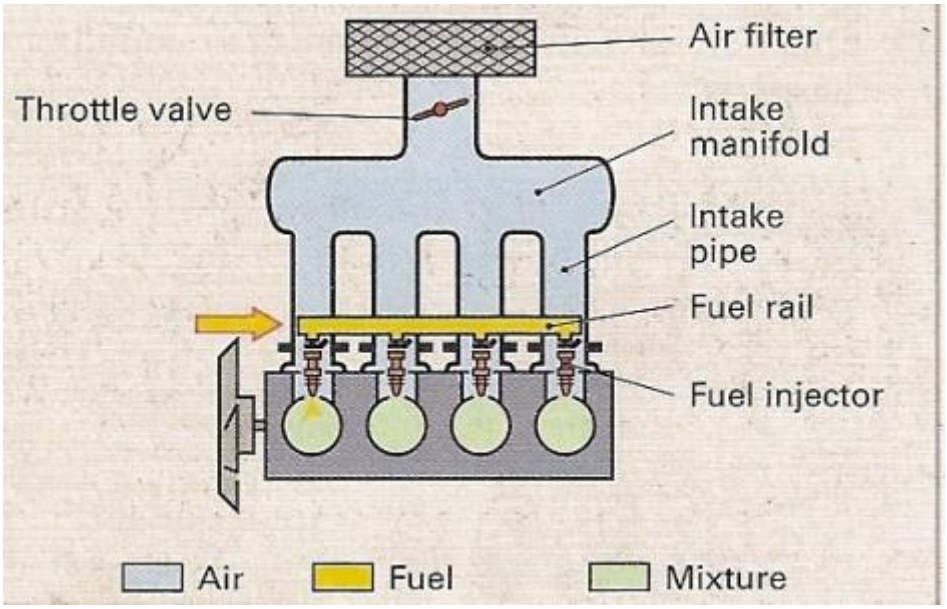


Figure 21 multi point injection sytem - direct injection

Opening of fuel injectors

The fuel injectors are hydraulically opened by the fuel pressure or electromagnetically opened.

Continuous injection (used on KE-Jetronic):

The injectors are forced open by the fuel pressure and remain open for the entire time that the engine is in operation. They inject fuel continuously. The fuel is apportioned by a variable system pressure.

Intermittent injection:

The injectors are electro-magnetically opened for a brief period only and, once the calculated injection quantity has been injected, closed again. They are therefore only intermittently opened. The fuel is apportioned by a variable opening time of the fuel injectors.

Depending on how the fuel injectors are actuated by the ECU, there are four different types of intermittent injection:

- ✓ Simultaneous injection
- ✓ Group injection
- ✓ Sequential injection
- ✓ Cylinder-specific injection

Simultaneous injection

All the engine fuel injectors are actuated simulta-neously. The time available for vaporising the fuel varies greatly for the individual cylinders. In order nonetheless to achieve as uniform a mixture com-position as possible and good combustion, half of the fuel quantity required for combustion is inject¬ed in each case per crankshaft revolution.

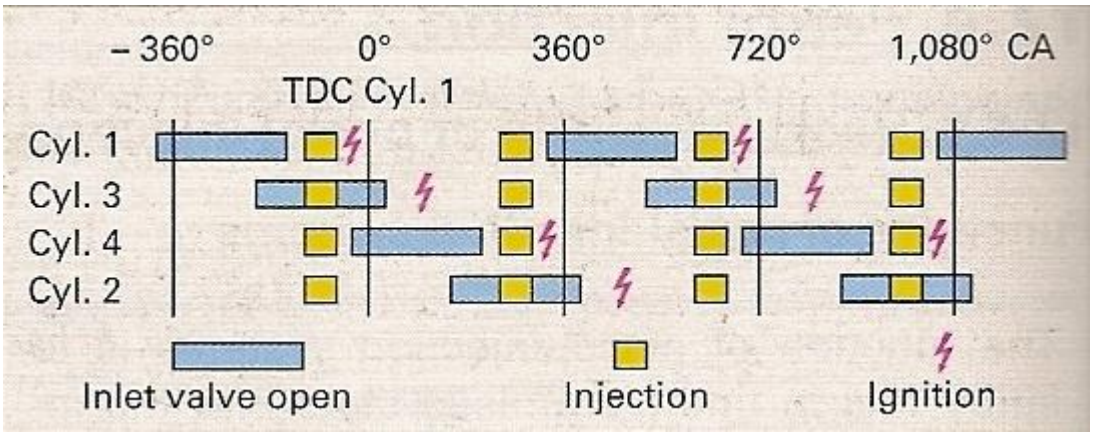


Figure 21 simulanous injection

Group injection

The fuel injectors of cylinder 1 and cylinder 3, and of cylinder 2 and cylinder 4, are opened once per power cycle. In each case the entire fuel quantity is injected before the closed inlet valves.The times for vaporising the fuel vary in length

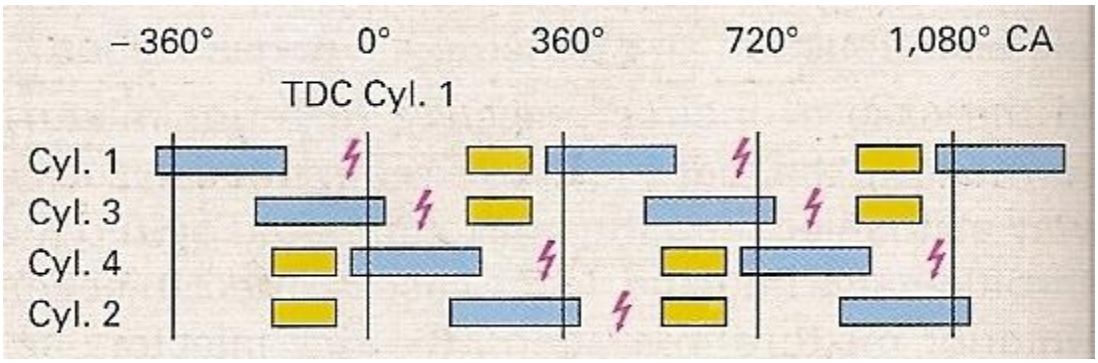


Figure 23 group injection

Sequential injection

The fuel injectors inject into the intake manifold the same entire fuel quantity in succession in firing sequence directly before the start of the induction stroke. This encourages optimal fuel-air mixture formation and improves internal cooling.

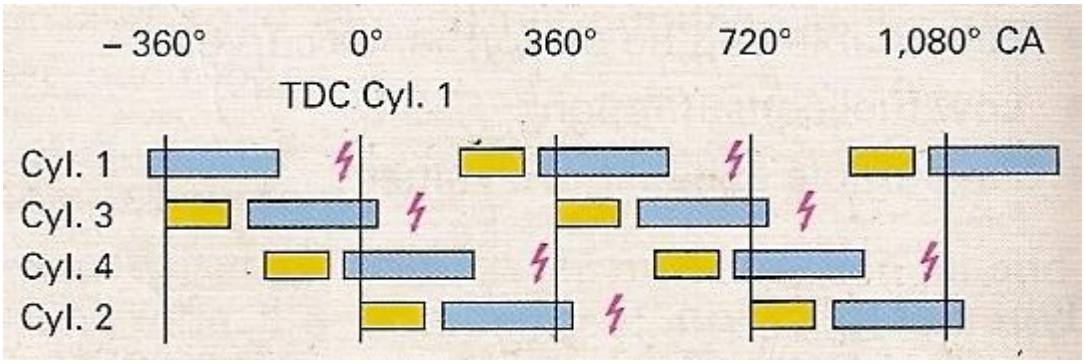


Figure 24 sequential injection

Cylinder-specific injection

This type of injection is a sequential-injection arrangement. Thanks to improved sensor technology and increased control sophistication, the ECU is able to apportion a specific fuel quantity to each individual cylinder

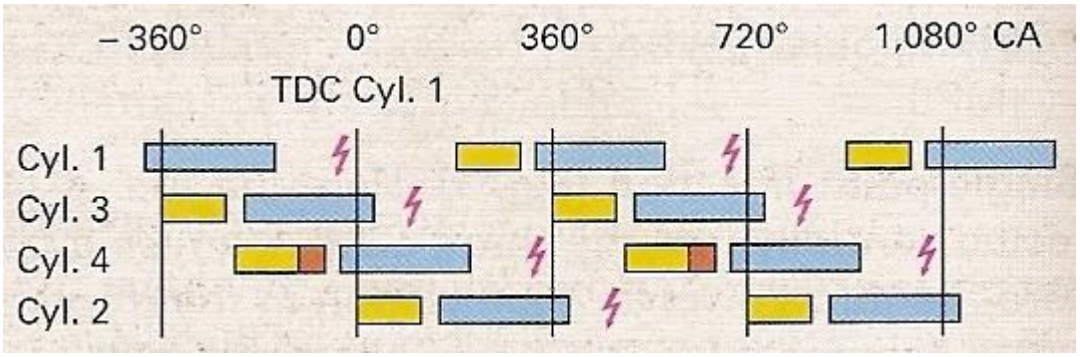


Figure 25 cylinder specific injection

- ✓ **Content/Topic 6 Description of K-jetronic**

K-Jetronic

- ✓ The K-Jetronic is a mechanically and hydraulically controlled fuel-injection system which needs no form of drive and which meters the fuel as a function of the intake air quantity and injects it continuously onto the engine intake valves.
- ✓ Specific operating conditions of the engine require corrective intervention in mixture formation and this is carried out by the K-Jetronic in order to optimize starting and driving performance, power output and exhaust composition.
- ✓ Owing to the direct air-flow sensing, the K-Jetronic system also allows for engine variations and permits the use of facilities for exhaust-gas after treatment for which precise metering of the intake air quantity is a prerequisite.
- ✓ The K-Jetronic was originally designed as a purely mechanical injection system. Today, using auxiliary electronic equipment, the system also permits the use of lambda closed-loop control.
- ✓ The K-Jetronic fuel-injection system covers the following functional areas:

  – Fuel supply,

  – Air-flow measurement and

  – Fuel metering.

Fuel supply

An electrically driven fuel pump delivers the fuel to the fuel distributor via a fuel accumulator and a filter. The fuel distributor allocates this fuel to the injection valves of the individual cylinders.

Air-flow measurement

The amount of air drawn in by the engine is controlled by a throttle valve and measured by an air-flow sensor.

Fuel metering

The amount of air, corresponding to the position of the throttle plate, drawn in by the engine serves as the criterion for metering of the fuel to the individual cylinders. The amount of air drawn in by the engine is measured by the air-flow sensor which, in turn, controls the fuel distributor. The air-flow sensor and the fuel distributor are assemblies which form part of the mixture control unit.

Injection occurs continuously, i.e. without regard to the position of the intake valve.

During the intake-valve closed phase, the fuel is “stored”. Mixture enrichment is controlled in order to adapt to various operating conditions such as start, warm up, idle and full load. In addition, supplementary functions such as overrun fuel cutoff, engine-speed limiting and closed loop lambda control are possible.

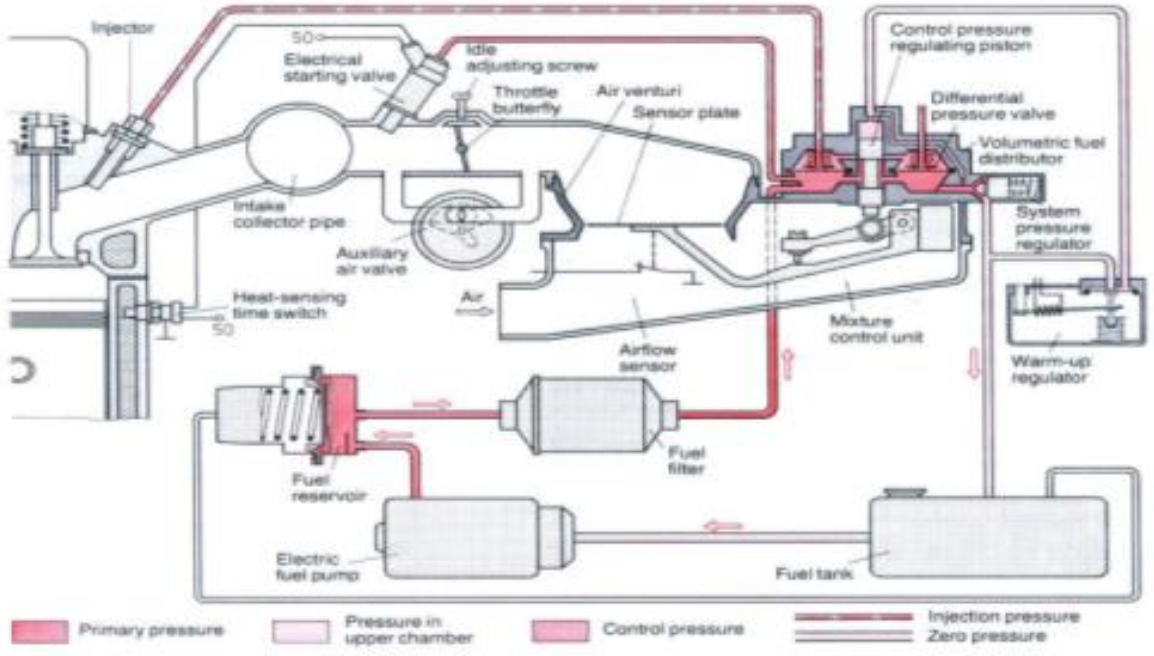


Figure 27 k jetronic fuel supply system

K jetronic Fuel supply components

The fuel supply system consists of the following parts:

- ✓ Fuel tank
- ✓ Electric fuel pump
- ✓ Fuel accumulator
- ✓ Fuel filter
- ✓ Pressure regulator
- ✓ Fuel distributor
- ✓ Injection Valves

The Fuel Tank

The fuel tank is the obvious place to start in any fuel system explanation - unlike the tanks on early carburettor fuelled engines it is a sealed unit. This allows the natural gassing of the fuel to aid delivery to the pump by slightly pressurising the tank it may be noted that when the filler cap is removed, pressure is heard to escape. Filler caps are no longer vented as previously found.

Electric fuel pump

The electric fuel pump is a roller-cell pump driven by a permanent-magnet electric motor. The rotor plate which is eccentrically mounted in the pump housing is fitted with metal rollers in notches around its circumference which are pressed against the pump housing by centrifugal force and act as rolling seals. The fuel is carried in the cavities which form between the rollers.

Electric fuel pump

1 Suction side, 2 Pressure limiter, 3 Roller-cell pump, 4 Motor armature, 5 Check valve, 6 Pressure side.

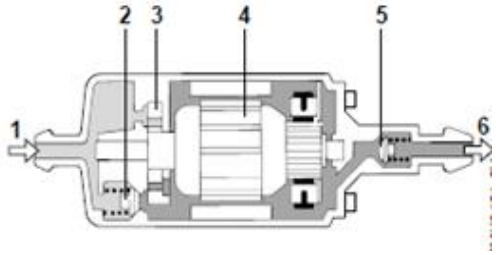


Figure 28 electrical fuel supply pump

The pumping action takes place when the rollers, after having closed the inlet bore, force the trapped fuel in front of them until it can escape from the pump through the outlet bore . The fuel flows directly around the electric motor. There is no danger of explosion, however, because there is never an ignitable mixture in the pump housing.

Fuel accumulator

- ✓ The fuel accumulator maintains the pressure in the fuel system for a certain time after the engine has been switched off in order to facilitate restarting, particularly when the engine is hot. The special design of the accumulator housing (Figure 8) deadens (absorbs) the sound of the fuel pump when the engine is running.

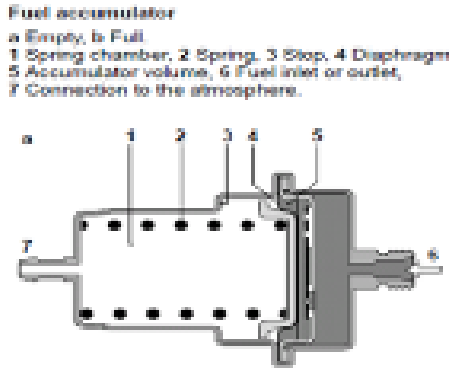


Figure 30 fuel accumulattor

- ✓ The interior of the fuel accumulator is divided into two chambers by means of a diaphragm. One chamber serves as the accumulator for the fuel whilst the other represents the compensation volume and is connected to the atmosphere or to the fuel tank by means of a vent fitting.

  During operation, the accumulator chamber is filled with fuel and the diaphragm is caused to bend back against the force of the spring until it is halted by the stops in the spring chamber. The diaphragm remains in this position, which corresponds to the maximum accumulator volume, as long as the engine is running.

Fuel filter

The fuel filter retains particles of dirt which are present in the fuel and which would otherwise have an adverse effect on the functioning of the injection system. The fuel filter contains a paper element with a mean pore size of 10 µm backed up by a fluff trap. This combination ensures a high degree of cleaning.

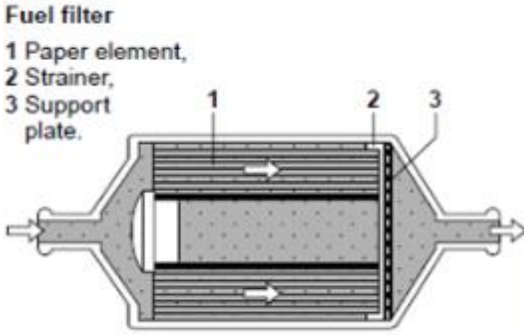


Figure 31 fuel filter

- ✓ The filter is held in place in the housing by means of a support plate. It is fitted in the fuel line downstream from the fuel accumulator and its service life depends upon the amount of dirt in the fuel. It is imperative that the arrow on the filter housing showing the direction of fuel flow through the filter is observed when the filter is replaced.

Primary-pressure regulator

- ✓ The primary-pressure regulator maintains the pressure in the fuel system constant.
- ✓ It is incorporated in the fuel distributor and holds the delivery pressure (system pressure) at about 5 bars.
- ✓ The fuel pumps always delivers more fuel than is required by the vehicle engine and this causes a plunger to shift in the pressure regulator and open a port through which excess fuel can return to the tank.

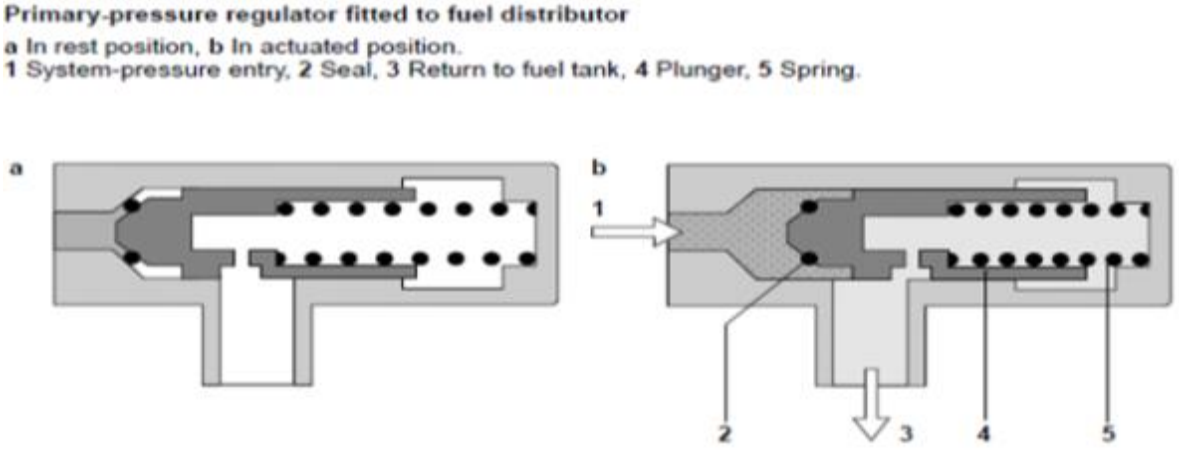


Figure 32 fuel pressure regulator

- ✓ The pressure in the fuel system and the force exerted by the spring on the pressure-regulator plunger balance each other out. If, for instance, fuel-pump delivery drops slightly, the plunger is shifted by the spring to a corresponding new position and in doing so closes off the port slightly through which the excess fuel returns to the tank. This means that less fuel is diverted off at this point and the system pressure is controlled to its specified level.
- When the engine is switched off, the fuel pump also switches off and the primary pressure drops below the opening pressure of the injection valves. The pressure regulator then closes the return-flow port and thus prevents the pressure in the fuel system from sinking any further.

Fuel-injection valves

The injection valves open at a given pressure and atomize the fuel through oscillation of the valve needle.

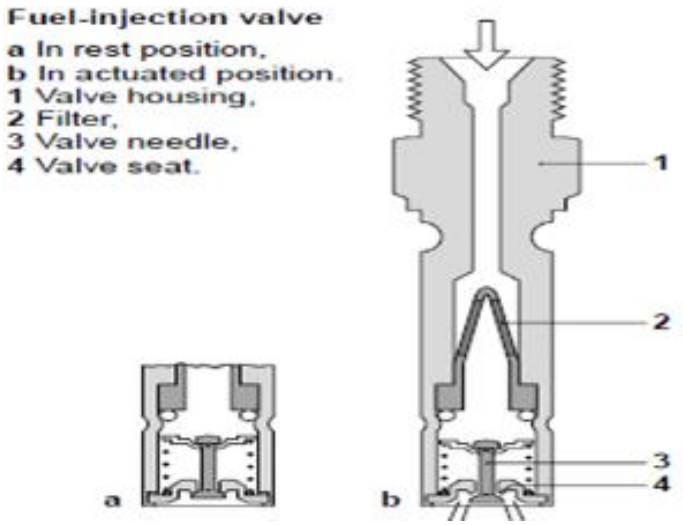


Figure 33 fuel injector valve

- ✓ The injection valves inject the fuel metered to them into the intake passages and onto the intake valves. They are secured in special holders to insulate them against the heat radiated from the engine. The injection valves have no metering function themselves, and open of their own accord when the opening pressure of e.g. 3.5 bars is exceeded. They are fitted with a valve needle which oscillates (“chatters”) audibly at high frequency when fuel is injected.
- This results in excellent Atomization of the fuel even with the smallest of injection quantities. When the engine is switched off, the injection valves close tightly when the pressure in the fuel-supply system drops.

Fuel metering

The task of the fuel-management system is to meter a quantity of fuel corresponding to the intake air quantity. Basically, fuel metering is carried out by the mixture control unit. This comprises the air-flow sensor and the fuel distributor.

In a number of operating modes however, the amount of fuel required deviates greatly from the "standard" quantity and it becomes necessary to intervene in the mixture formation system.

Air-flow sensor

The quantity of air drawn in by the engine is a precise measure of its operating load. The air-flow sensor operates according to the suspended-body principle, and measures the amount of air drawn in by the engine. The intake air quantity serves as the main actuating variable for determining the basic injection quantity.

A Small amount of air drawn in: sensor plate only lifted slightly, b Large amount of air drawn in: sensor plate is lifted considerably further.

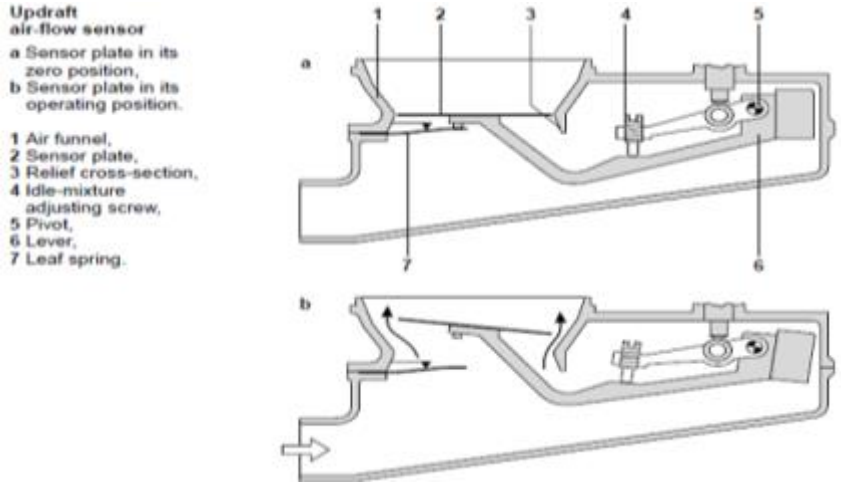


Figure 34 air flow sensor plate

- ✓ The air-flow sensor is located upstream of the throttle valve so that it measures all the air which enters the engine cylinders.
- ✓ It comprises an air funnel in which the sensor plate (suspended body) is free to pivot. The air flowing through the funnel deflects the sensor plate by a given amount out of its zero position, and this movement is transmitted by a lever system to a control plunger which determines the basic injection quantity required for the basic functions.
- ✓ Considerable pressure shocks can occur in the intake system if backfiring takes place in the intake manifold. For this reason, the air-flow sensor is so designed that the sensor plate can swing back in the opposite direction in the event of misfire, and past its zero position to open a relief cross-section in the funnel.
- ✓ A rubber buffer limits the downward stroke (the upwards stroke on the downdraft air-flow sensor). A counterweight compensates for the weight of the sensor plate and lever system (this is carried out by an extension spring on the downdraft airflow sensor). A leaf spring ensures the correct zero position in the switched-off phase.

Fuel distributor

Depending upon the position of the plate in the air-flow sensor, the fuel distributor meters the basic injection quantity to the individual engine cylinders. The position of the sensor plate is a measure of the amount of air drawn in by the engine. The position of the plate is transmitted to the control plunger by a lever.

Barrel with metering slits
1 Intake air, 2 Control pressure, 3 Fuel inlet,
4 Metered quantity of fuel, 5 Control plunger,
6 Barrel with metering slits, 7 Fuel distributor.

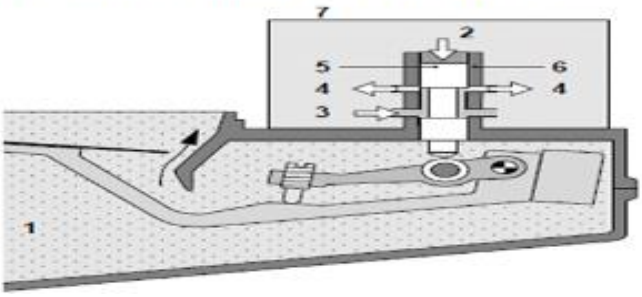


Figure 35 barrel with metering slits

- ✓ Depending upon its position in the barrel with metering slits, the control plunger opens or closes the slits to a greater or lesser extent. The fuel flows through the open section of the slits to the differential pressure valves and then to the fuel injection valves.
- ✓ If sensor-plate travel is only small, then the control plunger is lifted only slightly and, as a result, only a small section of the slit is opened for the passage of fuel. With larger plunger travel, the plunger opens a larger section of the slits and more fuel can flow. There is a linear relationship between sensor plate travel and the slit section in the barrel which is opened for fuel flow.

Barrel with metering slits and control plunger
a Zero (inoperated position), b Part load, c Full load.
1 Control pressure, 2 Control plunger, 3 Metering slit in the barrel, 4 Control edge, 5 Fuel inlet,
6 Barrel with metering slits.

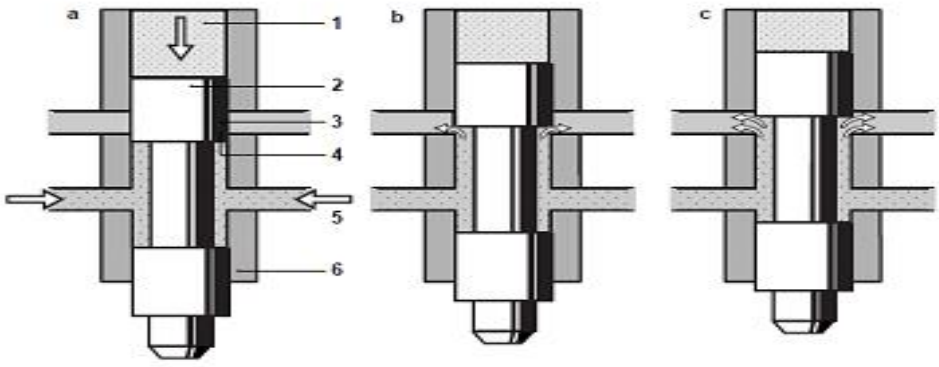


Figure 36 barrel with metering slits and control plunger

A hydraulic force generated by the so called control pressure is applied to the control plunger. It opposes the movement resulting from sensor-plate deflection.

One of its functions is to ensure that the control plunger follows the sensor-plate movement immediately and does not, for instance, stick in the upper end position when the sensor plate moves down again.

Further functions of the control pressure are discussed in the sections “Warm-up enrichment” and “Full-load enrichment”.

Control pressure

The control pressure is tapped from the primary pressure through a restriction bore. This restriction bore serves to decouple the control-pressure circuit and the primary-pressure circuit from one another. A connection line joins the fuel distributor and the warm-up regulator (control-pressure regulator).

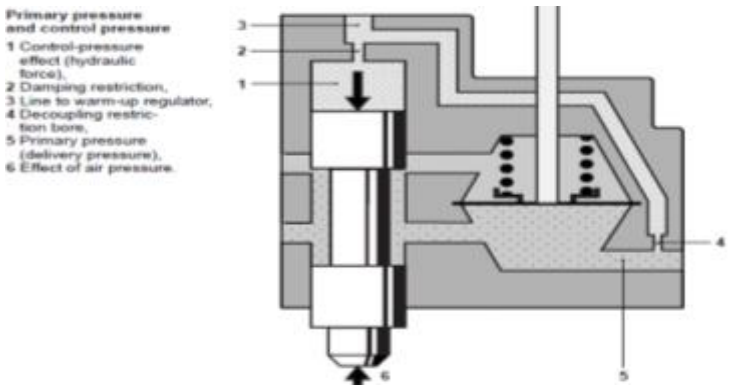


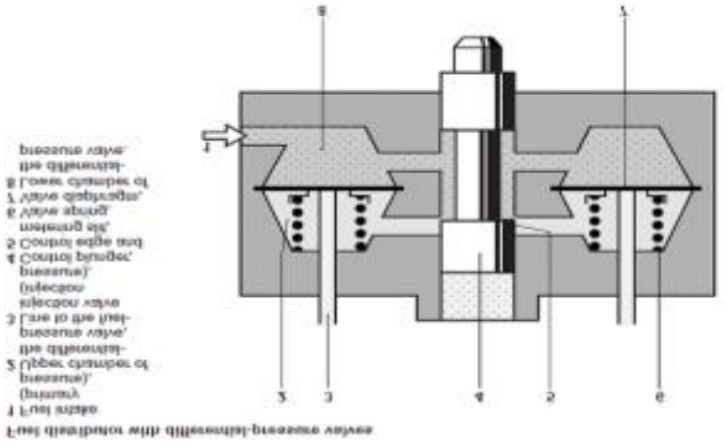
Figure 37 primary pressure and control pressure

- ✓ When starting the cold engine, the control pressure is about 0.5 bars. As the engine warms up, the warm-up regulator increases the control pressure to about 3.7 bars.
- ✓ The control pressure acts through a damping restriction on the control plunger and thereby develops the force which opposes the force of the air in the air-flow sensor. In doing so, the restriction dampens a possible oscillation of the sensor plate which could result due to pulsating air-intake flow.
- ✓ The control pressure influences the fuel distribution. If the control pressure is low, the air drawn in by the engine can deflect the sensor plate further. That results in the control plunger opening the metering slits further and the engine being allocated more fuel.
- ✓ On the other hand, if the control pressure is high, the air drawn in by the engine cannot deflect the sensor plate so far and, as a result, the engine receives less fuel. In order to fully seal off the control-pressure circuit with absolute certainty when the engine has been switched off, and at the same time to maintain the pressure in the fuel circuit, the return line of the warm-up regulator is fitted with a check valve.
- ✓ This (push-up) valve is attached to the primary-pressure regulator and is held open during operation by the pressure-regulator plunger.
- ✓ When the engine is switched off and the plunger of the primary-pressure regulator returns to its zero position, the check valve is closed by a spring.

Differential-pressure valves

- ✓ The differential-pressure valves in the fuel distributor result in a specific pressure drop at the metering slits.
- ✓ The air-flow sensor has a linear characteristic. This means that if double the quantity of air is drawn in, the sensor-plate travel is also doubled. If this travel is to result in a change of delivered fuel in the same relationship, in this case double the travel equals double the quantity, and then a constant drop in pressure must be guaranteed at the metering slits, regardless of the amount of fuel flowing through them.

- ✓ The differential-pressure valves maintain the differential pressure between the upper and lower chamber constant regardless of fuel through flow. The differential pressure is 0.1 bar.
- ✓ The differential-pressure valves achieve a high metering accuracy and are of the flat-seat type. They are fitted in the fuel distributor and one such valve is allocated to each metering slit. A diaphragm separates the upper and lower chambers of the valve.
- ✓ The lower chambers of all the valves are connected with one another by a ring main and are subjected to the primary pressure delivery pressure).
- ✓ The valve seat is located in the upper chamber. Each upper chamber is connected to a metering slit and its corresponding connection to the fuel-injection line. The upper chambers are completely sealed off from each other. The diaphragms are spring-loaded and it is this helical spring that produces the pressure differential.



Fugure 38 upper chamber and lower chamber

- ✓ **Content/Topic 7 Description of KE-Jetronic**

With KE-Jetronic the fuel injectors are opened continuously. The basic injection quantity is formed by mechanical-hydraulic means. Adaptation of the mixture to different operating states is electronically controlled. KE = German abbreviation for continuous petrol injection with electronic control.

Because the fuel injectors in this system are continuously opened, it is not possible to regulate the injected fuel quantity, as for example is the case with LH-Motronic, by means of the opening time. With KE-Jetronic the injected fuel quantity is regulated by means of the injection pressure.

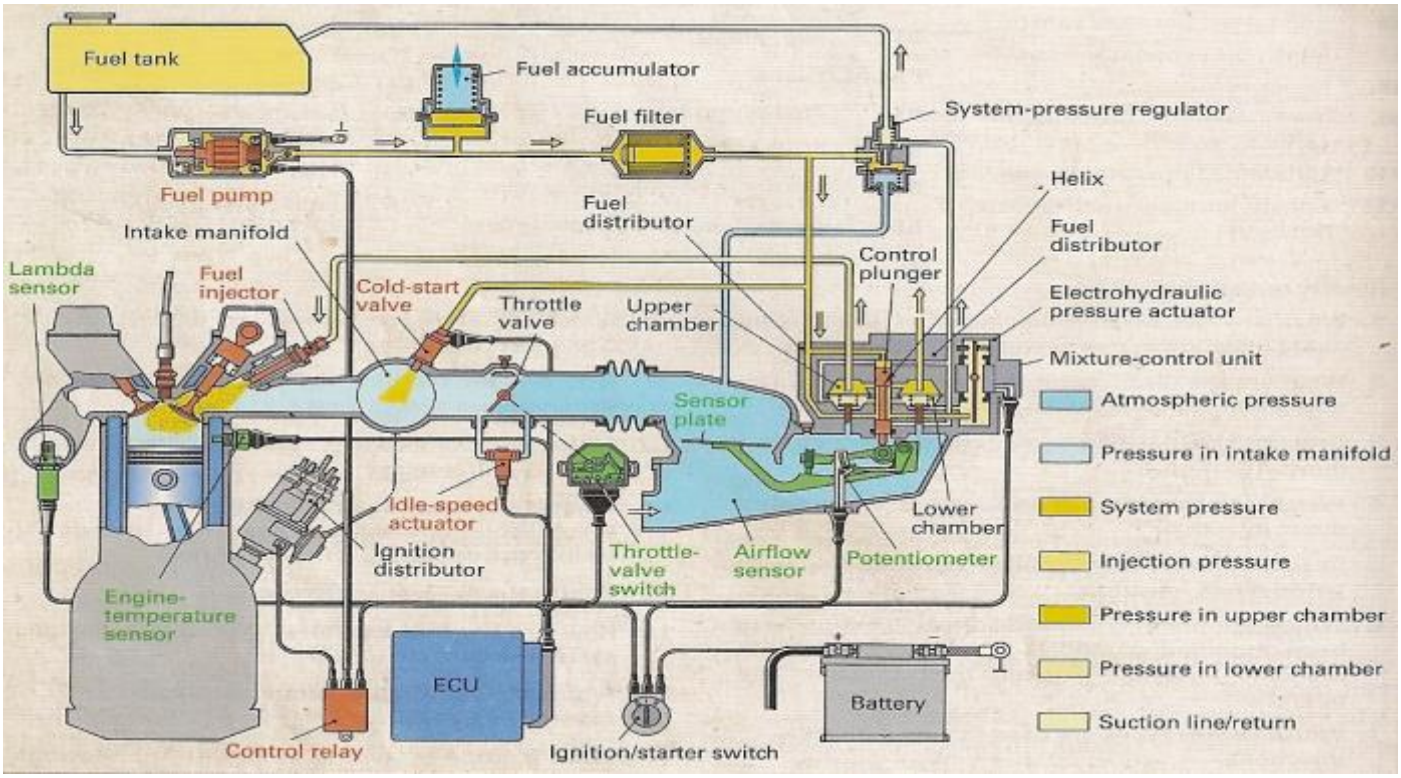


Figure39 KE jetronic fuel supply system

KE-Jetronic subsystems

Air system

The air filtered by the air filter, inducted by the engine and regulated by the throttle valve, flows into the intake manifold. Here the sensor plate, which is designed as a float, is raised to varying extents by the air flow. The deflection of the sensor plate is a measure of the inducted air flow. The deflection is transmitted as lift via a lever system to the control plunger in the fuel distributor.

Fuel system

An electric fuel pump generates the system pressure and delivers the fuel from the fuel tank to the fuel distributor. A fuel filter and a fuel accumulate' are connected downstream of the pump.

The fuel accumulator is designed to reduce the pulsation noises of the roller-cell pump, which is for the most part used as a fuel pump. It is on the other hand intended, when the engine is switched off, to maintain a residual pressure in the fuel system in order to prevent vapour bubbles from forming and to improve hot-starting capability. The system-pressure regulator used limits the system pressure, depending on the design, to 4.8 bar to 5.6 bar and returns the excess fuel to the fuel tank.

KE-Jetronic mixture-control unit

This consists of:

- ✓ Airflow sensor Fuel distributor
- ✓ Electrohydraulic pressure actuator

Airflow sensor

This sensor serves to determine the air flow inducted by the sensor. The flowing intake air raises the sensor plate. The control plunger in the fuel distributor is displaced by a lever mechanism in proportion to its deflection. A potentiometer incorporated on the lever system records the sensor-plate lift and transmits it in the form of a voltage signal to the ECU.

Fuel distributor

This distributes the basic fuel quantity to the individual cylinders in accordance with -5 sensor-plate position. Depending on the positions of the control plunger, which itself is dependent on the position of the sensor plate, the control- plunger helix opens up for example at idle a small discharge cross-section (orifice) in the slot barrel.

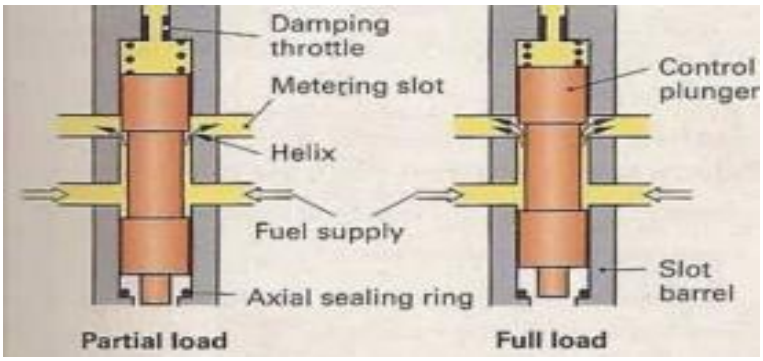


Figure 40 fuel distributor

In this way, only a small amount of fuel can flow into the upper chamber. At increased load the plunger is z solaced upwards and the discharge cross-section s widened, thereby admitting an increased supply fuel into the upper chambers each cylinder in the engine has its own upper chamber and lower chamber. The upper chambers are separated each cylinder in the engine has its own upper chamber and lower chamber. The upper chambers are separated from the lower chambers by a steel diaphragm.

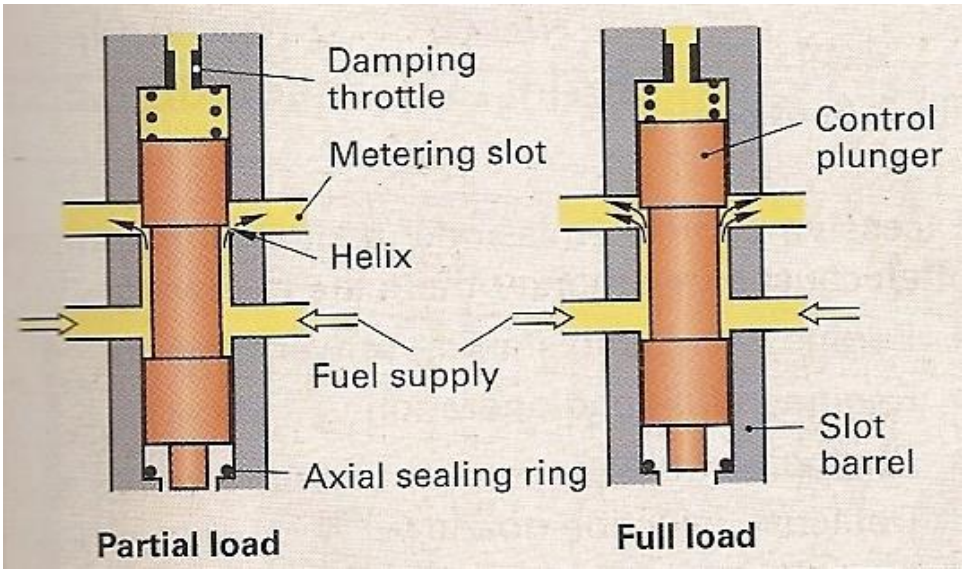


Figure 41 control plunger (A) partial load (B) Full load

They are called differential-pressure valves because they are set in such a way that the z-assure differential between upper and lower chamber is always 0.2 bar. When the pressure in the upper chamber increases on account of an increase in the fuel supply, the steel diaphragm deforms down

wards against the spring pressure and the fuel pressure in the lower chamber. In this way, the outlet cross section to the fuel injector is widened, slowing more fuel to flow to the fuel injectors.

The injectors are hydraulically opened as soon as the pressure at valve exceeds 3.3 bar and close only when the engine is switched off or in the event of overrun fuel cut-off.

Electrohydraulic pressure actuator

The ECU can adapt the mixture by means of this actuator to the respective operating states. Its pivoted baffle plate can be deflected by the ECU depending on the power supplied to the solenoid coil.

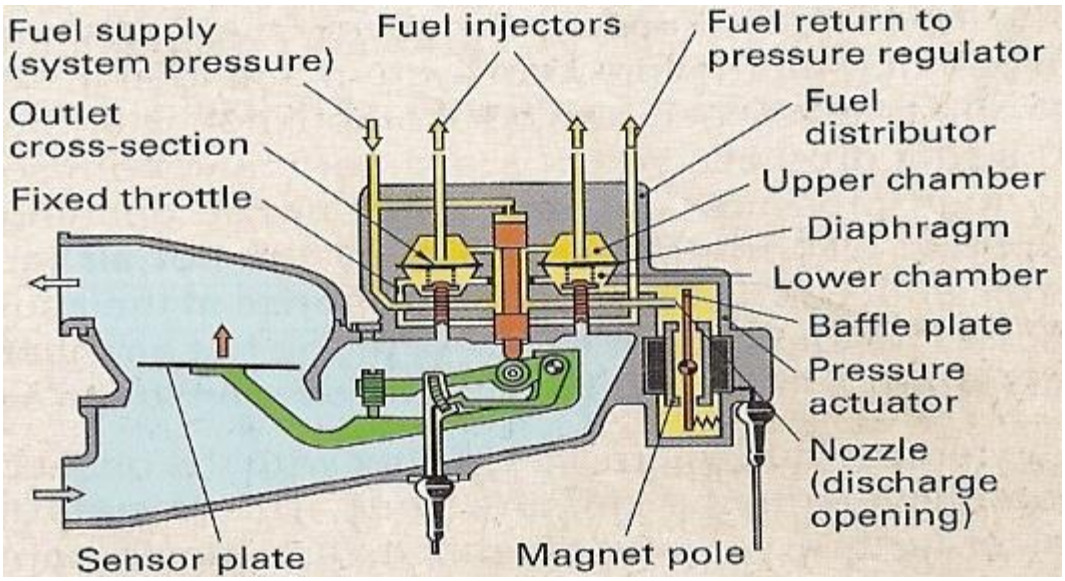


Figure 43 KE jetronic electrohydraulic control

When the discharge opening of the nozzle is widened by the baffle plate moving away from the nozzle opening, increased fuel can flow into the pressure actuator. This causes the pressure to rise in the lower chambers of the differential-pressure valves, which are connected to the pressure actuator. This in turn causes the steel diaphragm to arch upwards slightly and the discharge cross-section in the upper chambers to narrow. In this way, less fuel flows to the injectors and the mixture leans. The mixture is enriched when the solenoid coil is energised in such a way that the baffle plate moves towards the nozzle opening.

The ECU requires the following signals for mixture adaptation:

- ✓ Throttle valve switch - idle, full load
- ✓ speed sensor- engine speed
- ✓ ignition/starter switch - start
- ✓ engine temperature sensor - coolant temperature
- ✓ lambda sensor - mixture composition

In the event of electronic control failure, the basic injection quantity can continue to be formed by mechanical- hydraulic control system, the vehicle can therefore continue to be driven. However the mixture can no longer be adapted.

- ✓ **Content/Topic 8 Description of L-Jetronic**

L- JETRONIC PETROL INJECTION SYSTEM

Introduction

L- Jetronic fuel injection system is an electronically controlled fuel injection system reference.

Fuel is supplied by an intermittent action L- jetronic fuel injection system, which uses intake air flow meter as it main control parameters.

Each cylinder has its own solenoid injector, which is opened by control pulses delivered by the electronic control unit, the length of these pulses depends the control parameters. All of these parameters are detected by the sensors and processed by in the control unit.

"**L**" it is a nick name derived from Germany: Luft, meaning air flow into the engine is measured by a movable vane (indicating engine load) known as the air flow meter sensor

Function of L- jetronic petrol injection system

The function of L- jetronic fuel injection system is to spray the fuel into a finely atomized state and injects into the induced air in the intake manifold by the injectors which are electromagnetically opened for a brief period, determined by the electronic control unit (ECU)

In this system of L-jetronic petrol injection, some components which can causes rapid wear and unequal fuel injected quantity to which injector are replaced by the electronic component which has capacity to regulate the mixture quantity which is required.

Design of L-jetronic petrol injection system

- ✓ The L- jetronic is a pure intermittent electronic fuel injection system, by which the quantity of air drown into the engine is directly measured and acts as the major control for the quantity of a fuel supplied
- ✓ The fuel is measured by means of electronically controlled injection valves. The remain under constant fuel pressure and the length of time for which they remain open, proportional to the fuel intake, is controlled electronically by optimal information from different electrical transmitters for every operating condition.
- ✓ These include choke switch, idling and full load signals and the cold start valve, which is operated for the engine temperatures below-15^{o}c by means of a temperature dependent. Thermal switch to provide a fuel enriched mixture. The construction and the operating methods of the L-jetronic are precisely described.
- ✓ The low pollutant valves of the exhaust gases can be further reduced by the conclusion of a catalysts the operation of the engine under precisely measured air fuel behavior.

L-jetronic consists of several devices such as:

- ➢ **Fuel supply system:** the fuel supply system is composed by: fuel pump, fuel filter, fuel pressure regulator, fuel rail, fuel injectors, fuel tank and cold start valve.
- ➢ **Air intake system:** air filter, airflow meter, throttle valve and intake manifold as housing.

L-jetronic electrical components: electric fuel pump, auxiliary air valve, main injectors and cold start valves and thermo time switch.

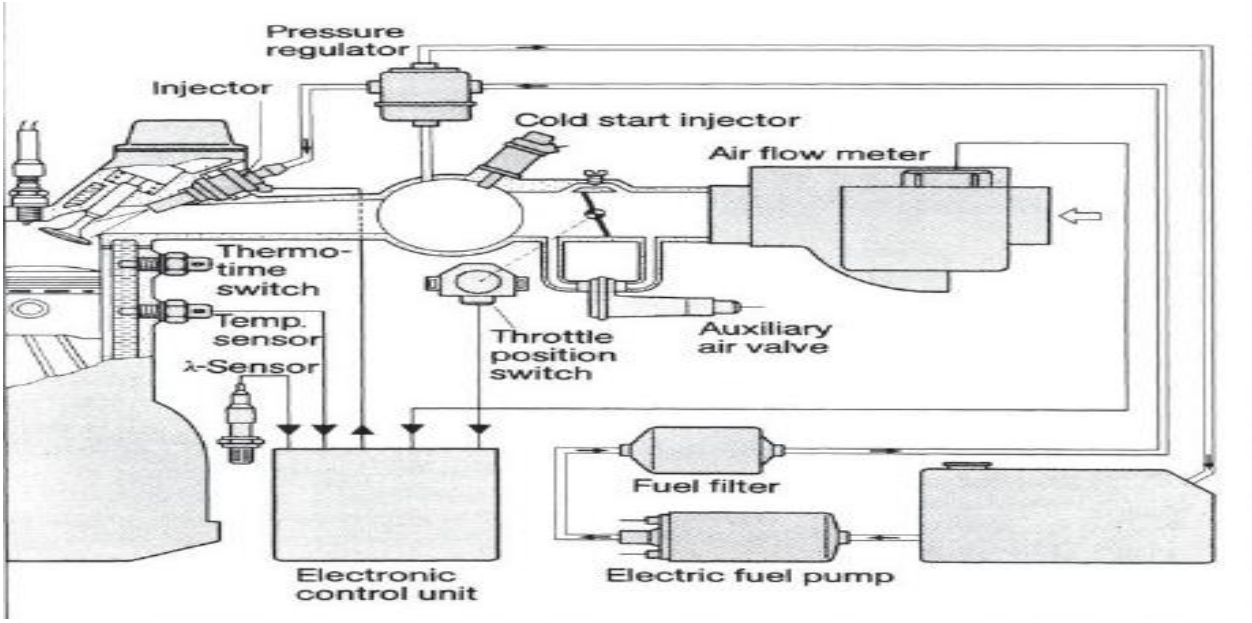


Figure 44 L jetronic sytem

Fuel supply system components

1.Fuel tank (petrol tank)

Is a container for flammable fluids, it is typically applied to part of an engine system in which the fuel is stored and propelled by the fuel pumper released (pressurized gas) into an engine.

A fuel tank must allow or provide the following:

- ✓ **Storage of fuel:** the system contains a given quantity of fuel and must avoid leakage and limits evaporative emissions.
- ✓ **Filling:** the fuel tank must be filled in a secure way, without sparks.
- ✓ Provide method for determining level of fuel in a tank, gauging**.**
- ✓ **Venting:** if over pressure is not allowed, the fuel vapors must be managed through valves
- ✓ Feeding of the engine; through a pump

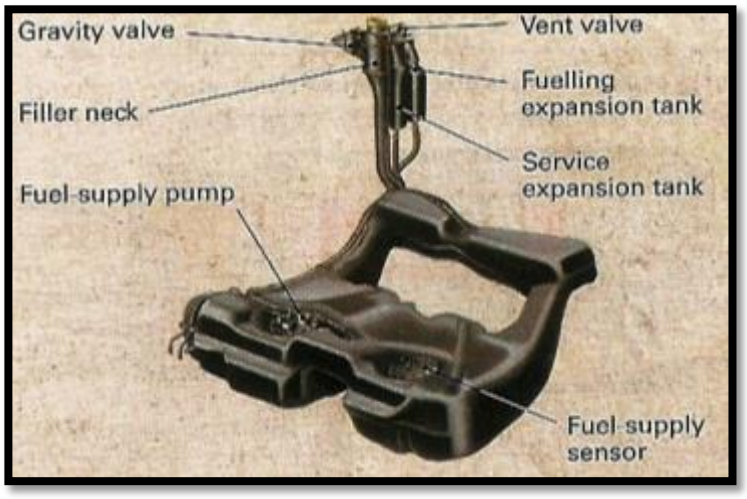


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Figure 45 fuel tank

2. Electric fuel pump

The electric fuel pump is a rotary pump. It is involved permanently and provided more than the engine to need. It is a roller-cell pump driven by a permanent- magnet mounted in the pump housing is fitted with metal rollers in notches around its circumference which are pressed against the pump housing by centrifugal force and acts as rolling cells. The fuel is carried in the cavities which form between the rollers.

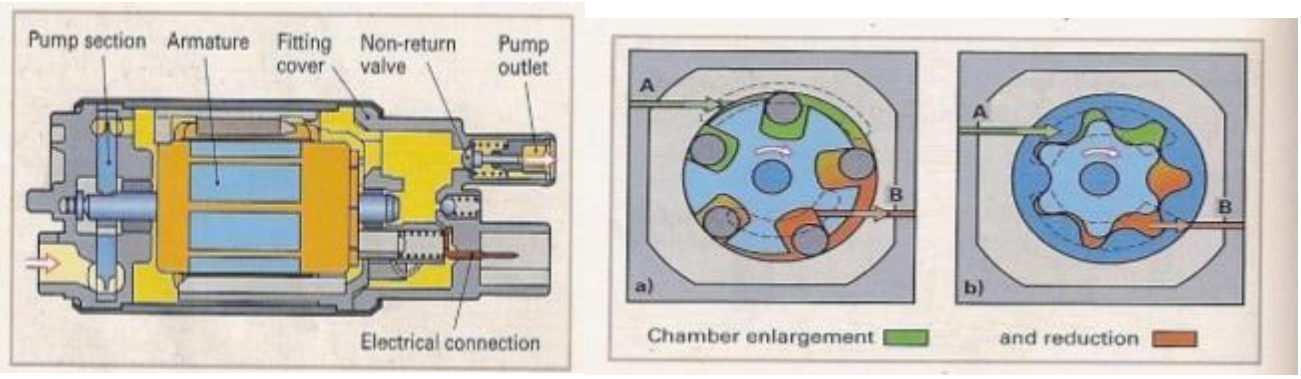


Figure 46 electric fuel pump

The electric fuel pump sends the fuel from the tank through filter to the input hopper which is connected with the injectors at the end of input hopper there is the regulator of supply pressure. That drives back a surplus of fuel toward the tank

3. Fuel filter

A fuel filter in the fuel line that screens out dirt and dust particles from the fuel, normally made into cartridges containing a filter paper. They found in most internal combustion engine. It used to remove the contaminants which are in the fuel in order to protect the injection system against the impurities in the fuel. Contaminant in the fuel can impair the operation of both pressure regulator and injectors.

After is therefore installed downstream from the electric fuel pump. The replacement intervals are determined by the filters volume and contamination level in the fuel.

Fuel filters serves a vital functions in to days modern, tight- tolerance engine fuel system. It needs to be maintained at regular intervals. If a filter is not replaced regularly it may become clogged with contaminants and cause a restriction in the fuel flow, causing an appreciable drop in engine performance as the engine struggles to draw enough fuel to continue running normally

Figure 47 fuel filter

4. Fuel rail

Is known as common rail, is essentially a pipe used to deliver fuel to individual fuel injectors on internal combustion engine. The injectors are mounted on the fuel rail, which also usually includes a fuel-pressure regulator. Fuel rail are used on engines with multi- point fuel injection system, although some multi- point system are used as fuel distributer with individual pipes or tubes to feed each injector. It contains a large volume than the quantity of fuel necessary during a complete cycle of the engine.

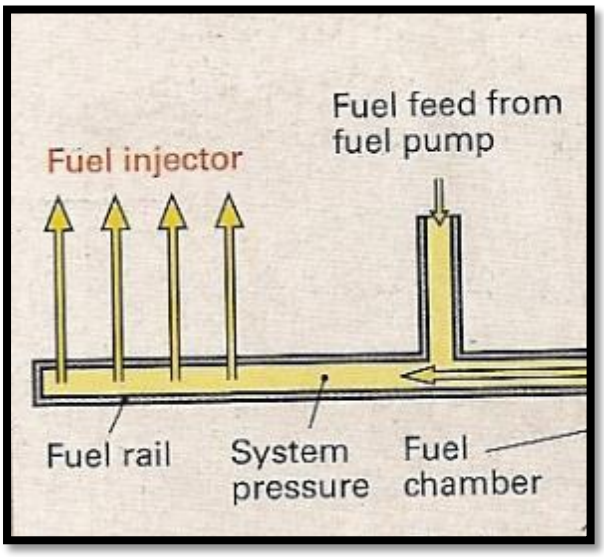


Figure 48 fuel line

It accumulates and equalizes the fuel vibrations. Fuel rails have the main function for consists in the **optimal distribution** of the fuel (gasoline, methane) to the injector in high or low pressure supply system.

4.1 Rail pressure control valve

The rail pressure control valve also known as fuel pressure regulator, regulates the amount of fuel pressure generated in the rail and amount of fuel returning to the tank to maintain a constant pressure drop across the injectors.

This adjust the rail pressure as a function of the engine load state and operating condition and maintain this pressure at constant level. The pressure control valve is closed at zero current. It is variably opened by the ECU

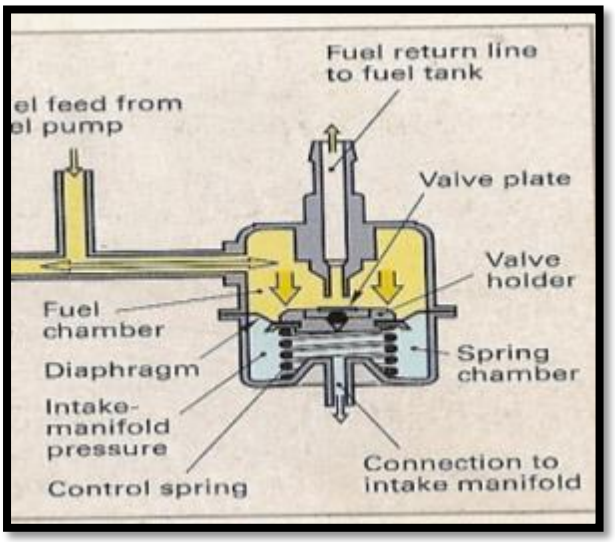


Figure 49 fuel pressure regulator

4.2 Main injectors and cold start valves injectors

The injector facilitates precise control of the start of injection and injected fuel quantity as well as pre- and post- injection.

The injectors consist of the following components:

- ✓ Solenoid valve
- ✓ Valve control plunger
- ✓ Valve control chamber
- ✓ Injection nozzle

Main injector

The operating principle of the main injector

The injector has the positive current, but it misses the ground, the ECU has to establish the earth (ground) or to make negative current in order to open the injector by presence of electric field in solenoid. The ECU has to control the current for commanding injector either to open or closed it.

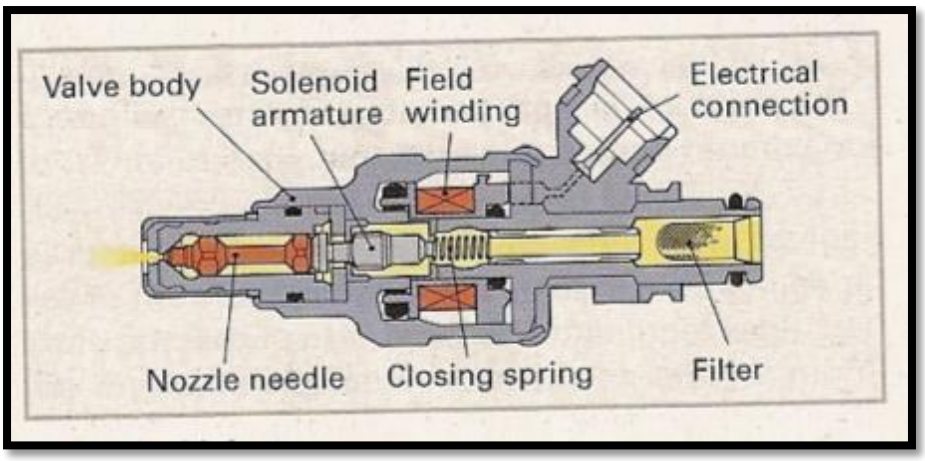


Figure 50 electric fuel injector

4.3 Cold start valve injector

- ✓ The cold- start valve is a solenoid operated valve. An electromagnetic winding in fitted inside the valve. When UN operated, the movable electromagnet armature is forced against a seat by means of a spring and thus closed the valve. When cold starting the engine voltage is applied to cold the start valve and the thermo-time.
- ✓ If the temperature of the engine is above approximately +35^{o}c, when the starting process is commenced, the thermo-time switch will have already open circuit the connection to the start valve which consequently, does not inject extra fuel.
- ✓ When the electromagnetic is energized, the armature which consequently has lifted from the valve seat opens the passage for the flow of fuel through the valve. The fuel enters a special nozzle at a tangent and is caused to rotate or swirl
- ✓ Cold starting injector Injects during cold starting, the injector of cold start injects during time that the engine is cold with starting an additionary quantity of fuel.
- ✓ The result is that the fuel is atomized very finely and enriches the mixture in the manifold downstream of the throttle valve.
- ✓ The cold start-start valve is positioned in the intake manifold that good distribution of the mixture to all cylinders.

Air intake system

- **air filter**

Air filter: is a device composed of fibrous material which removes solid particulates such as dust, pollen, mold and bacteria from the air. A chemical air filter consists of an absorbent or catalyst for the removal of air born molecular contaminants such as volatile organic compounds or ozone.

Air filters are used in applications where air quality is important notably in building ventilation system and in engines.

Figure 51 air filter

- ✓ **air flow meter**

An air flow meter: is a device that measures air flow, eg: how much air is following through a tube. It does not measure the volume of air passing through the tube. It measure the actual speed of the air flowing through the device in a defined time segment. The air flow meters are simply an application of mass flow meters for special medium. Typically, mass air flow measurement are expressed in the unity of kilogram per second (kg/s)

In the flow meter of air the shutter is probes, which is maintained under the tension of a spring helical. The shutter probe is actuated by the drought admitted at the time of the aspiration against the force of the spring. The shutter of compensation is fixed at the shutter probes and equalizes the mechanical vibration coming from outside (oscillations, vibrations of the engine)

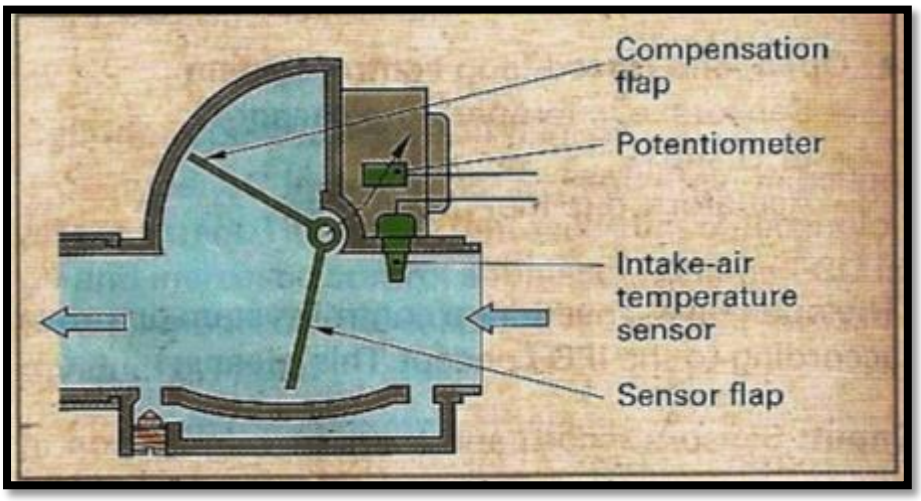


Figure 52 air flow sensor

Mixture formation of L-jetronic fuel injection system

According to the information from further sensors in different operating conditions, these information are sent to the ECU as the voltage signals, the electronic control unit (ECU) actuates the fuel injectors to spray the fuel into the intake manifold depending up on the inducted air measured by the air flow meter and controlled by the throttle valve The fuel-air mixture is formed in the intake manifold to the back of inlet valve where it is stored for waiting to be admitted into the cylinder.

Characteristics of L- jetronic fuel injection system

L-jetronic fuel injection system has the following some features:

- ✓ The measurement of the quantity of the air is done by the air flow meter.
- ✓ The transfer of signal is electric; there is no more mechanical function.
- ✓ The electronic control unity receives information about function of the engine.
- ✓ The electronic control unity calculates the length of opening of injectors, corresponding to the opening time.
- ✓ Electromagnetic injectors inject fuel under shapes of impulses.
- ✓ The fuel supplies a sufficient quantity with a constant pressure.

Operating principle of L-jetronic fuel injection system

An electric fuel pump send the fuel from fuel tank through the fuel filter into the fuel rail where is stored in high pressure. The fuel in the rail is taken to each injector which is electro magnetically opened by electronic control unit (ECU). Depending up on the information received by the ECU, the ECU determines the required voltage signals to be send to the injector then the injector sprays the fuel quantity into the intake air manifold on the back of the inlet valve corresponding to the inducted air.

The fuel vaporizes and mixes with the air which comes from outside through the air flow meter and throttle valve, this mixture is stored in the intake manifold for waiting to be used.

When the pressure of fuel in the system gets too high, the fuel pressure regulator returns the excess fuel pressure back into the tank in order to maintain the constant pressure in the system.

✓ **Content/Topic 9 Description of LH-Jetronic**

LH- JETRONIC PETROL INJECTION SYSTEM

✓ **Introductions**

The LH- jetronic system is an electronically controlled fuel injection system with multipoint injection, in which the air mass is used as one of the main controlled variable. LH –jetronic is a further developed variant of L- jetronic, the electromagnetic fuel injectors are sequentially actuated by the ECU. The fuel is injected into the intake manifold shortly before the engine inlet valve, which are still closed at the start of injection. Engine speed and inducted air mass are used as the main controlled variables.

- ✓ In intermittent injection system they tried to replace the mechanical devices by electronic devices in order to avoid wear.
- ✓ All LH-jetronic systems (fuel injection system) are essentially designed as motronic systems.
  i.e both mixture formation and ignition of the fuel air mixture is controlled by a common engine ECU.
- ✓ By using motronic systems, it possible to reduce design complexity, increase operational reliability and improve the efficiency of the systems.
- ✓ LH- motronic injection system is an electronically controlled fuel injection system with multipoint injection in which the air mass **is used as one of main controlled variable.** It is further developed variant of L-jetronic. The electromagnetic fuel injectors are sequentially actuated by the ECU. The fuel is injected in the intake manifold shortly before the engine inlet valve which is still closed at the start of injection.

Design of LH-jetronic system

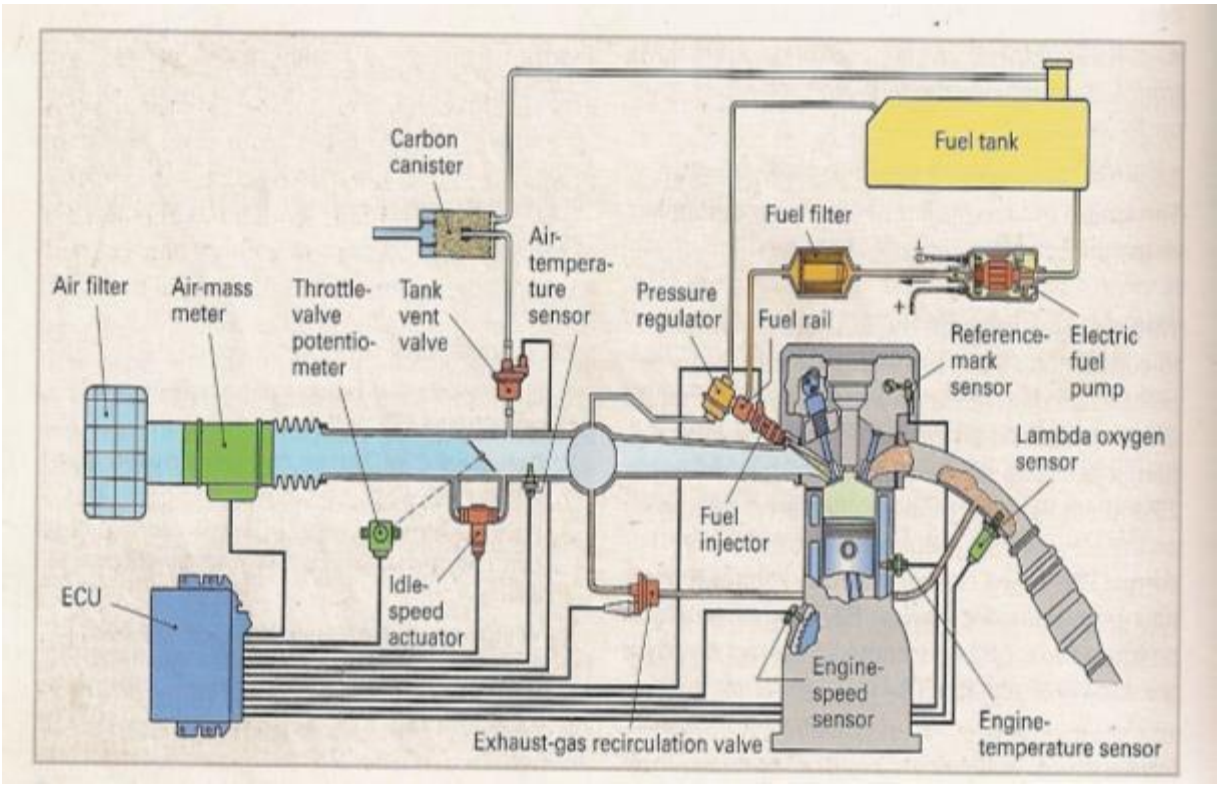


Figure 53 LH jetronic fuel supply system

1 Air-intake system

The air inducted and filtered in the air filter flows through into the intake manifold. There the air mass is recorded by the air mass meter and transmitted to the ECU in the form of an electrical voltage signal. An NTC resistor, which can also be integrated in the air mass meter, is used as the air temperature sensor. The voltage drop at the thermostat is the measure of the air temperature.

2 Fuel system

An electric fuel pump delivers the fuel from the fuel tank via a fuel filter to the central injection unit (fuel rail). At the end of the fuel rail is a pressure regulator which keeps the differential pressure constant at approx 3.5 bars. The excess fuel returns from the pressure regulator to the fuel tank.

3 Regenerating system

The hydro carbon temporally stored in the carbon canister must be supplied for combustion in an appropriate operating state, e.g: part load. For this purpose, the regenerating valve is clocked by the ECU so that air and hydrocarbons can be drowning in by the vacuum pressure acting in the intake manifold.

4 Exhaust gas recirculation

An exhaust gas recirculation system can be used to improve the exhaust gas values.

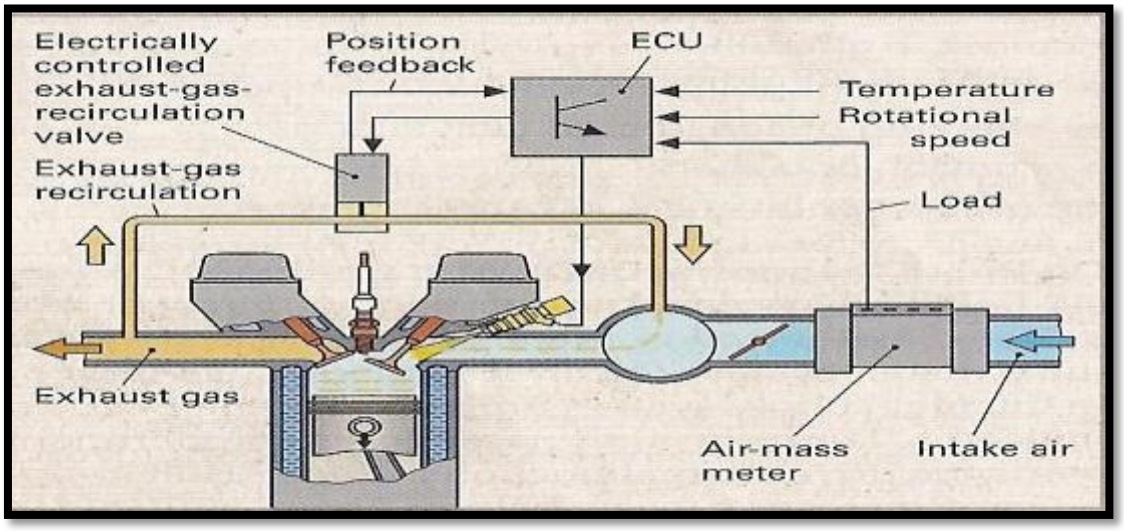


Figure 54 LH jetronic exhaust gas recirculaion system

✓ **Mixture formation of LH-Jetronic fuel injection system**

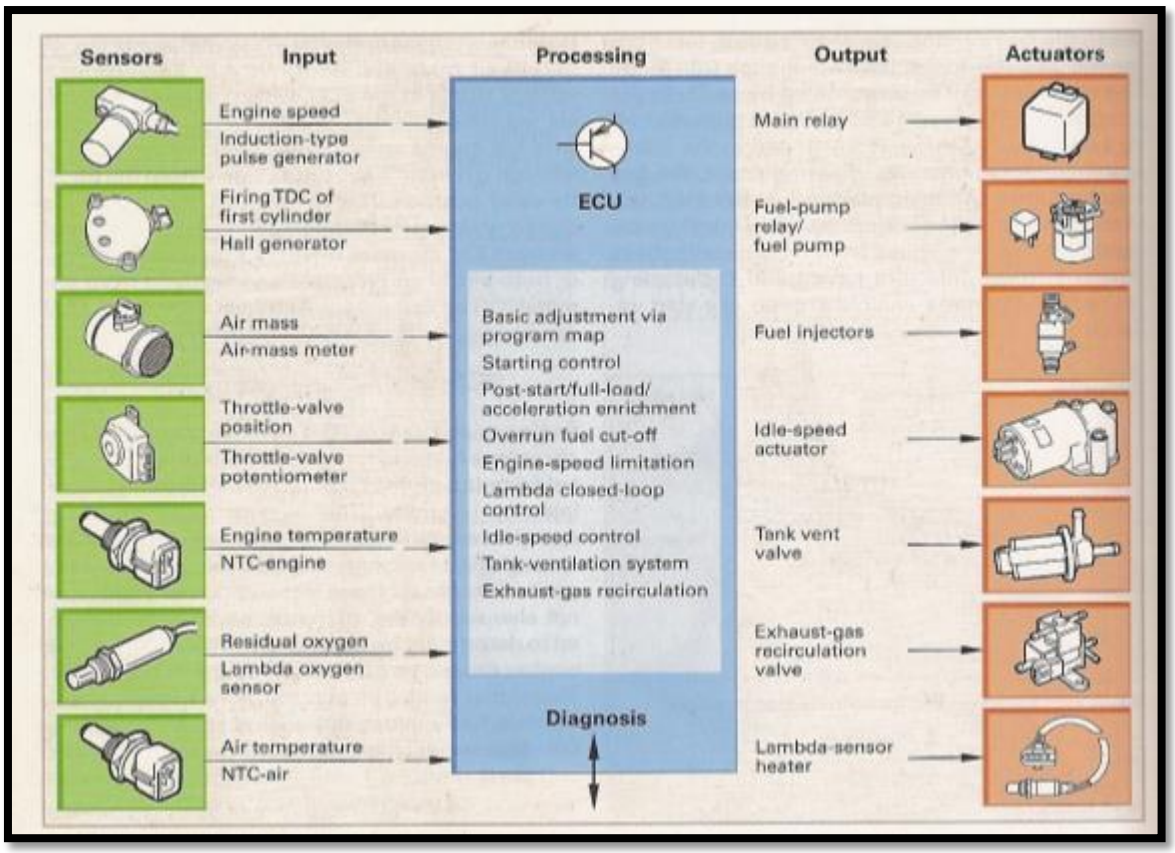


Figure 55 electronic control of LH-Jetronic fuel injection system

Idle speed control

- ✓ Its function is to keep the engine speed constant with the throttle valve closed at a set point value dependent on the engine temperature the internal resistance levels of the engine when the engine is cold are greater than when it is hot on account of the viscous engine oil and increased friction.
- ✓ In order to overcome this resistance and facilitate stable idle speed, the engine must generate more power . This is achieved by an increased amount of mixture.
- ✓ The ECU requires the signals from the following sensors for idle speed control:
- ✓ -Engine speed sensor (actuator speed)
- ✓ Engine temperature sensor (determination of the set point speed)
- ✓ **One of the following actuators is used for speed control**

Idle speed actuator (rotary actuator)

- ✓ This permits additional air depending on the requirement to flow in a bypass around the closed throttle valve. For this purpose, it is actuated by the ECU by means of pulse width. Modulated signals, a process which opens the air duct to lesser or greater extent.

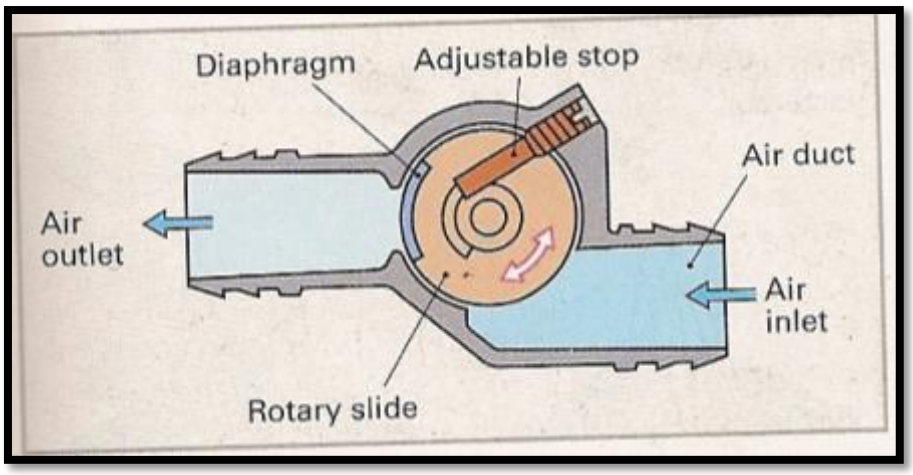


Figure 56 idle speed actuator

Throttle valve actuator

- ✓ This subassembly consists of an electric motor, the throttle gearing and the throttle valve . At idle the electric motor is actuated by the engine ECU in such a way that it opens or closes throttle valve depending on the actual speed so that a specified set point speed is maintained.

Overrun fuel cut-off

- ✓ No fuel is injected when overrun fuel cut-off is acting when the engine is running with increased revs and with the throttle valve closed (over running, eg ; in downhill driving situation),overrun fuel cut-off prevents fuel from being injected . Fuel injection resumes when the throttle valve opens or when the engine speed drops below a stored threshold, example: 1200RPM.

The ECU requires the flowing information for over run fuel cut off:

- Throttle valve position from the throttle vale switch or throttle valve potentiometer
- Engine speed from the engine speed sensor

Acceleration, full load enrichment

- ✓ The mixture is enriched in order to facilitate maximum engine power output. Engine with three way catalyst are operated as for as possible in the λ=1 range of account of exhaust gas regulations. To be able to output the maximum engine power,. The inducted mixture is enriched, depending on the engine to lambda o.85 to 0.95. Lambda closed loop control must be cut out for this purpose. Enrichment begins when the throttle valve potentiometer signal full load to the ECU or the voltage change per unit of time at the potentiometer exceed a specific stored. Extremely power full engines don't necessary require full load enrichment.

Altitude adaptation

- ✓ There is no need for special altitude adaptation in non-supercharged engines because the air mass meter takes into account a reduced air density for instance at greater altitudes.

Engine speed limitation

- ✓ The function of this facility is to prevent the engine from over revving. Engine speed limitation is activated when the ECU receives from which it detect that the stored maximum speed has been

reached. The moment of ignition is moved in the retired direction to limit the power and with it the maximum speed and also the top road speed. The fuel injection is cut out in exceptional cases only.

Characteristics of LH- jetronic fuel injection system

- ✓ Measurement air mass with hot-wire air mass meter or hot film air mass meter
- ✓ No wear of the mechanical component
- ✓ The measurement of the air mass is direct
- ✓ No need for the devices of correction of temperature
- ✓ No need for the devices of correction of altitude
- ✓ Electronic adjustment of the idle speed

Comparisons between LH and L-jetronic fuel injection system

- ✓ The intermittent injection system L-jetronic one tries to replace the mechanical devices in order to avoid wear. As we know L-jetronic uses air flow meter to determine air quantity, this air flow meter is replaced by hot wire air mass meter. The name of this injection system called LH-jetronic delivered to the replacement of air flow meter by hot wire air mass meter. The other functions are identical with L-jetronic as it is shown two below sketches

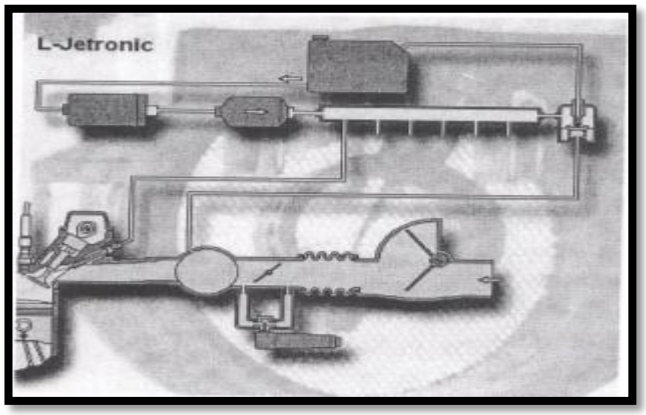
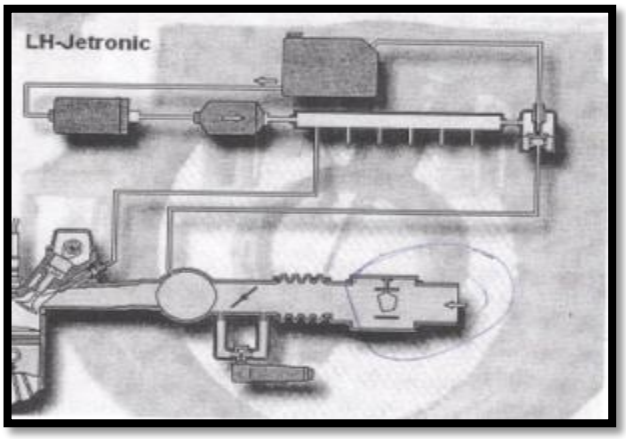
L jetronic	**LH jetronic**
	

Figure 57 comparison between L and LH jetronic

- **Content/Topic 10 Description of ME-Motronic**

- ✓ ME-Motronic is a further development of LH-Motronic.
- ✓ A significant innovation is the replacement of mixture-formation control by so- called torque management. This has made it necessary to use electronic throttle control (ETC function). EOBD has also been integrated in the system.

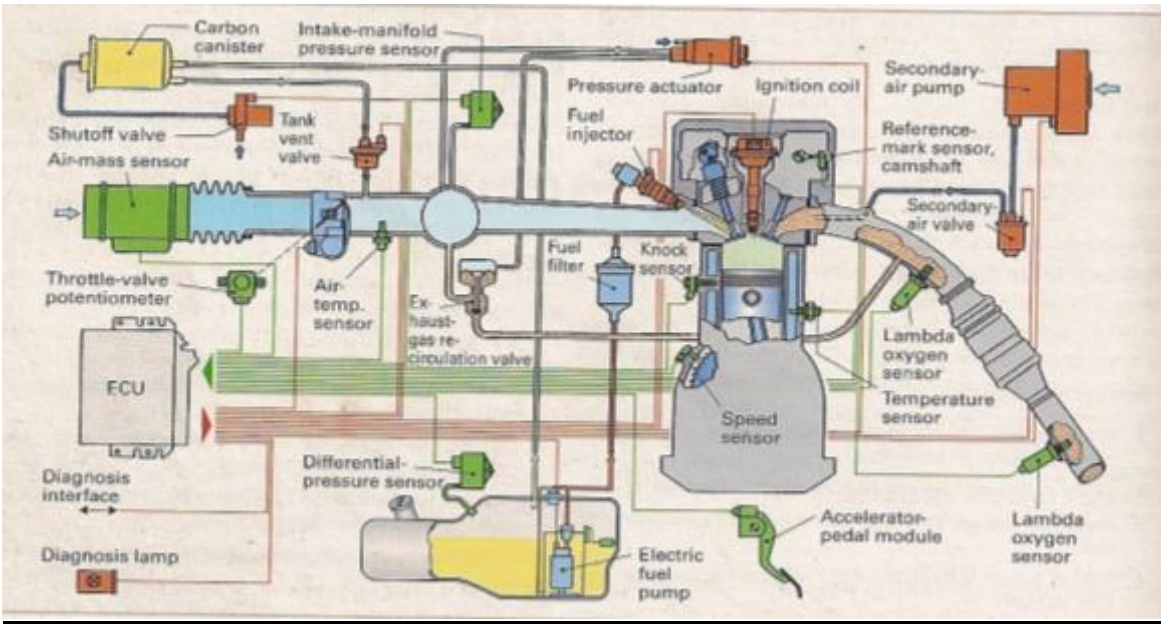


Figure 58 ME Motronic system

- ✓ In previous systems the driver opened and closed the throttle valve by operating the accelerator pedal. The inducted air mass and the fuel quantity injected accordingly determined together with the engine speed (main controlled variables) the torque requested by the driver.
- ✓ Additional torque requests, e.g. by the A/C compressor, occurred as disturbance values and had to be corrected by the system, e.g. by idle-speed control. Because of torque management, the accelerator-pedal position is now no longer the sole deciding factor for the torque to be generated. All the systems and components which influence the drive torque, e.g. automatic gearbox, A/C compressor, catalyst heaters, TCS/ASR, ESP, are used to calculate the engine torque to be generated.
- ✓ Motronic generates a substitute value, on which the requirements of the individual systems have an influence with different priorities. When, for instance, the A/C compressor is switched on, the drive torque is reduced.
- ✓ In order to avoid this, the ECU receives a signal before the A/C compressor is cut in. This causes the torque to be generated to be modified by the required amount by means of opening c; the throttle valve, increased fuel injection and ir other cases also a modified ignition angle.
- ✓ To facilitate this, it is necessary to isolate the throttle- valve position from the accelerator-pedal position, This is achieved by using an ETC (electronic throttle control) function. This also means that the accelerator-pedal position is from now on only to be viewed as a driver command, e.g. in the case of a TCS intervention.

ME-Motronic subsystems

Air-intake system

A significant, visible difference from LH-Jetronic is the introduction of the so-called ETC function. For this purpose, the driver command is recorded via an accelerator-pedal module. This is performed for safety reasons by two redundant potentiometers or Hall-effect sensors which are integrated in the module. The position and the rate of motion of the accelerator pedal are transmitted by the generated voltage signals to the engine ECU. The ECU uses stored program

maps to calculate a necessary and useful torque and moves the throttle valve to a corresponding position by means of a servo-motor. This position is monitored by two potentiometers. Thus there is no longer any mechanical connection at all between the accelerator pedal and the throttle valve (drive by wire). In the event of faults within the system caused by unclear sensor signals, the throttle valve is moved into a limp-home position.

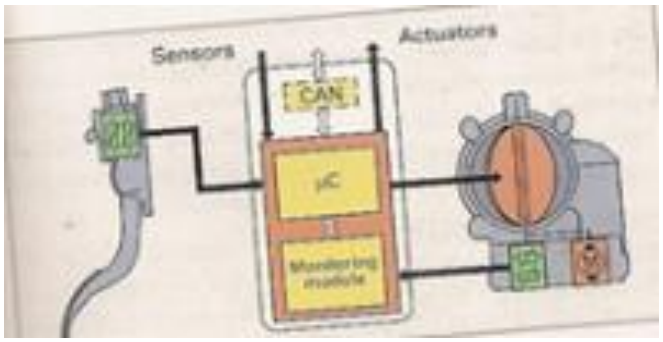


Figure 59 acceletor pedal with ETC function

Fuel system

The fuel supply is increasingly supplied by one-line systems and delivery modules integrated in the tank. When one-line systems (Returnless Fuel Systems) are used, the fuel supply pressure is usually kept constant at 3 bar in relation to the ambient pressure. As the intake-manifold pressure varies, so the differential pressure at the fuel injector changes, which results in different injected fuel quantities. This fault is corrected by a compensation function. For this purpose, the intake-manifold pressure is recorded by an intake-manifold pressure sensor and the injection time is extended or shortened by the ECU accordingly.

Pollutant-reducing systems

The increasingly stringent environmental-protection legislation passed over the years calls for pollutant-reducing subsystems to be elaborated and improved.

Mixture-formation system

- ✓ More precise recording of the inducted air mass by hot-film air-mass meters with return-flow detection enable the engine to be operated in a narrower lambda window.
- ✓ The recording of the lambda value by broadband lambda sensors enables the lambda value to be regulated more precisely than was previously possible with voltage-jump sensors.
- ✓ The use of rapid-starting pulse-generator wheels on the camshaft enables the firing-TDC position to be detected earlier and therefore the engine to be started more quickly.

Tank-ventilation system

The fuel-supply system is outwardly sealed airtight. The carbon canister can 3e ventilated by a shutoff valve, which is connected n parallel to the regenerating valve.

Exhaust-gas recirculation

Cooling the exhaust gases recirculated in the combustion chamber improves NOX reduction. An exhaust-gas recirculation cooler is installed for this purpose.

Electronic control of ME-Motronic

In addition to the sensors and actuators used in LH- Motronic, the following components are used:

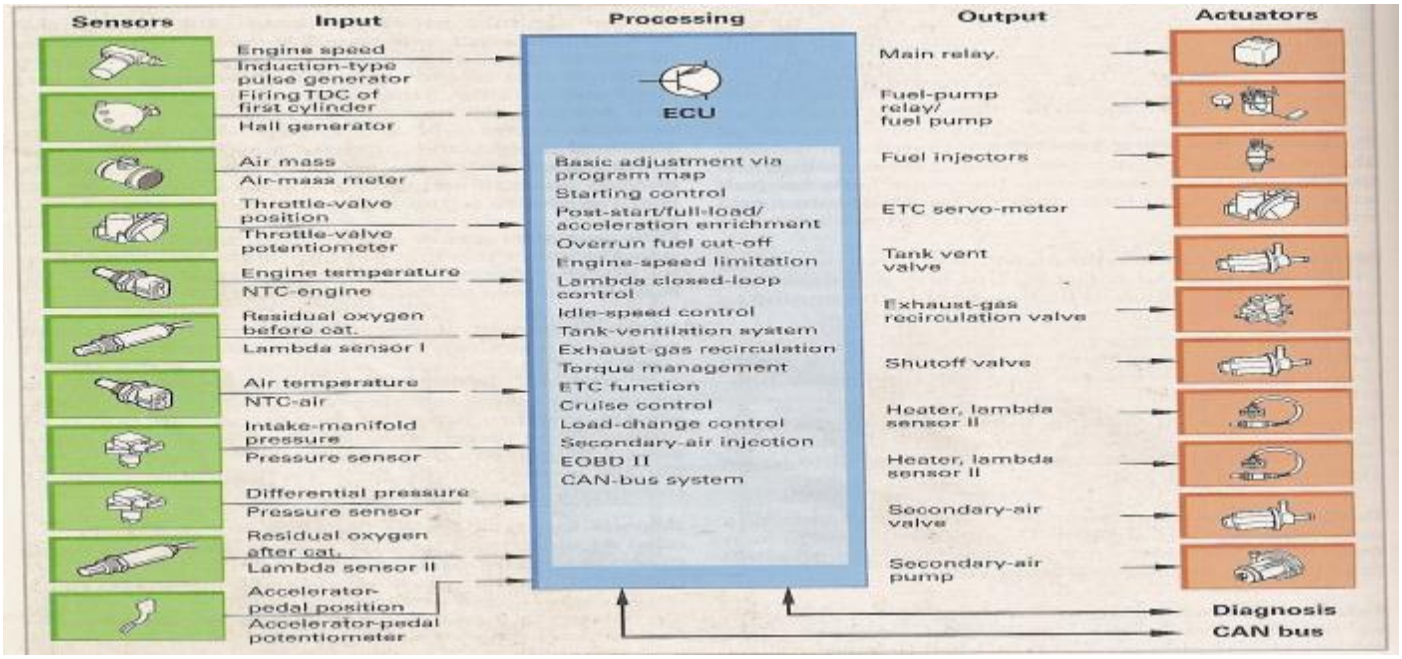


Figure 60 electronic control of ME Motronic

✓ **Content/Topic 11 description of MED-Motronic**

MED-Motronic

MED-Motronic (D - direct injection) is a Motronic system which is derived from ME-Motronic and adapted to the particular conditions and requirements of direct injection.

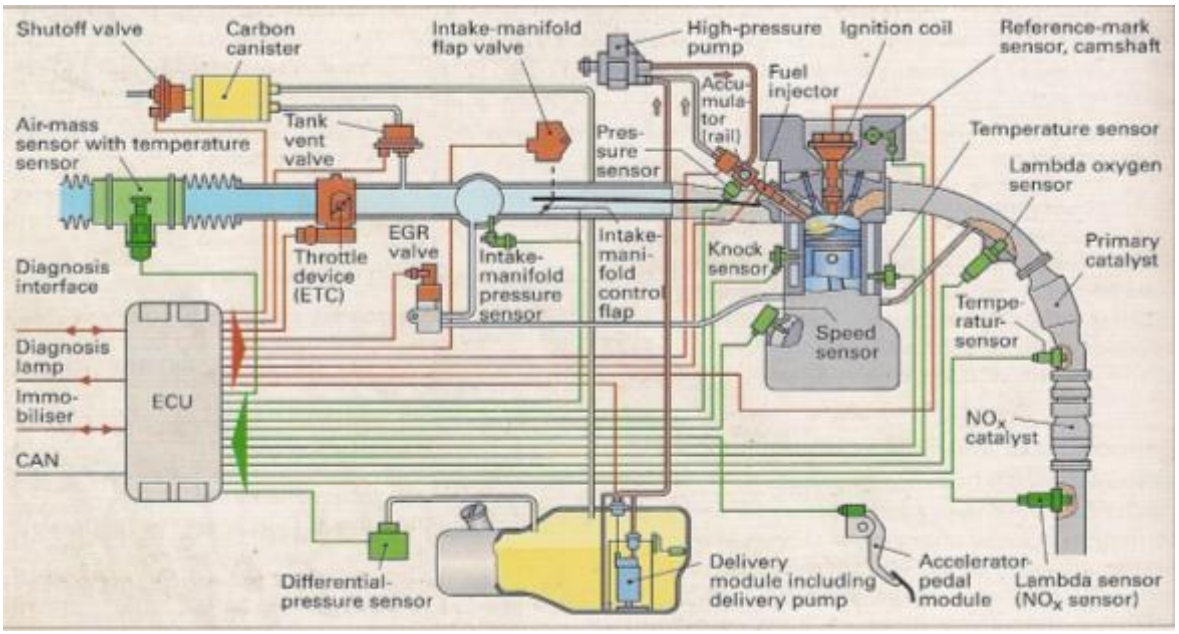


Figure 61 MED Motronic fuel supply system

✓ Virtually all manufacturers have taken to developing petrol direct injection because it offers the following advantages over indirect injection:

- ✓ Because the liquid fuel is injected directly into the combustion chamber, the liquid fuel vaporises in the combustion chamber only, which results in good internal cooling and increased engine power.
- ✓ Stratified-charge operation enables the engine to permit higher exhaust-gas recirculation rates.
- ✓ At partial load very much higher effective internal pressures are achieved on account of quality regulation. Throttling losses are reduced in stratified-charge operation by the fully opened throttle valve. This results in greater efficiency, increased power and reduced fuel consumption.
- ✓ During cold starting or acceleration the mixture has to be enriched less with direct injection than it do with indirect injection, these result in better exhaust-gas values and reduced consumptions.

These advantages are offset by the following dis-advantages:

- ✓ The significantly higher expenditure incurred in design and control
- ✓ The increased emission of NOX due to a lean mixture in stratified-charge operation, which cannot be reduced in the three-way catalyst.
- ✓ This makes it necessary to use a NOX accumulator- type catalyst which must be regenerated at specific intervals. Furthermore, the sulphur in the fuel reduces the effectiveness of the catalyst.

Operating modes with petrol direct injection

The following operating modes can be used with petrol direct injection:

- ✓ Stratified-charge operation
- ✓ Homogeneous-charge operation
- ✓ Homogeneous lean operation
- ✓ Homogeneous stratified operation
- ✓ Homogeneous knock-protection mode
- ✓ Stratified-catalyst-heating operation

These operating modes are matched to each other so as to provide optimal mixture formation and combustion in every operating state. The control system must ensure that during vehicle operation neither power nor torque jumps are perceptible when switching from one operating state to another.

LO 1.3 – Describe diesel fuel supply

- ✓ **Content/Topic 1 Description of diesel fuel supply components**

Introduction

A diesel engine uses a fuel system with a precision injection pump and individual fuel injectors. The pump delivers fuel to the injectors at a high pressure and at timed intervals. Each injector sprays fuel into the combustion chamber at the precise moment required for efficient combustion. The major part of the diesel fuel supply system are the fuel tank, fuel filter, fuel pump, fuel line, injection pump and injectors.

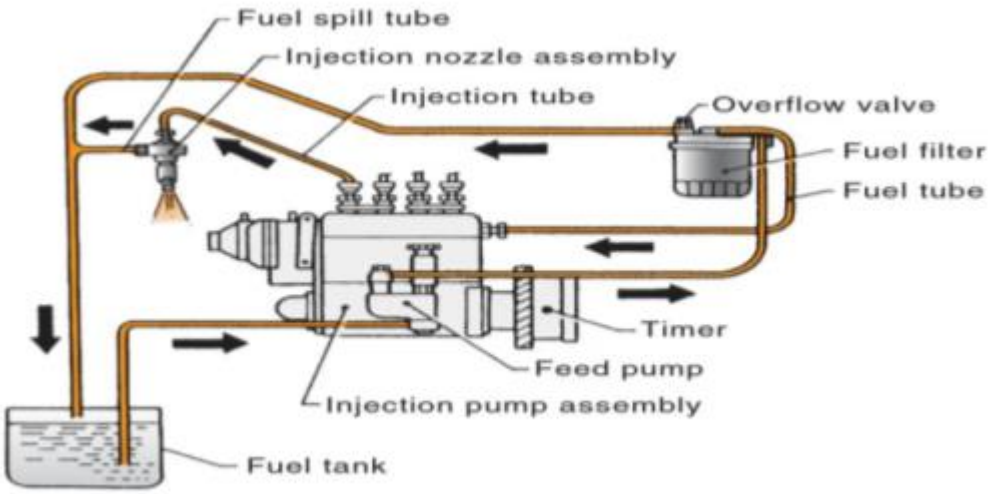


Figure 63 diesel fuel supply system

Fuel supply components

1. **Fuel tank**

Fuel tank is the one of the most component that include in the diesel fuel supply system, its function to **store the fuel** that will supply to the diesel engine and also is a reservoir help to maintain its temperature at level below its flash point. It must also use some mean to prevent excessive pressure accumulation such as a vent or safety valve.

2. **Pre-supply pump or feed**
   - ✓ It pumps the diesel at a low pressure to the fuel injection pump through a filter.
   - ✓ In order for the fuel injection system to fulfil its purpose, fuel must be transferred to it from the fuel tank.
   - ✓ This is the role of the low-pressure fuel system components. The low pressure side of the fuel system consists of a number of components including the fuel tank, one or more fuel supply pumps and one or more fuel filters. In addition, many fuel systems contain coolers and/or heaters to better control fuel temperature.
3. **Fuel filter**

Fine fuel filter is designed for final fuel cleaning. It is unseparable; the fuel going through the paper filter element curtains gets cleaned from mechanic impurities. Before diesel is supplied to an engine, it must be filtered to remove any unwanted impurities.

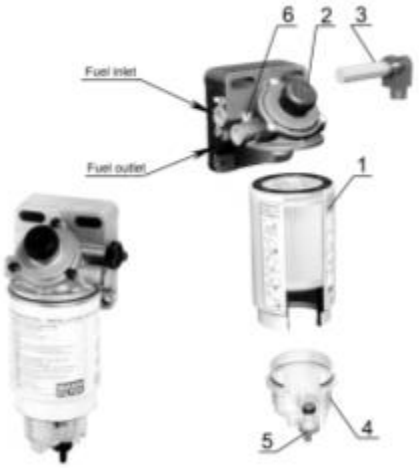


Figure 64 diesel fuel filter

4. **Fuel lines**
   - ✓ A fuel line is a hose used to bring fuel from one point in vehicle to another or from a storage tank to a vehicle. It is commonly made of reinforced rubber to prevent splitting and kinking.
5. **Injectors**
   - ✓ Fuel injector sprays a fine mist of fuel into the combustion chamber of each cylinder or throttle body depending on the design.
   - ✓ These are designed to inject fuel into the combustion chamber in such a way as to provide optimal mixture formation for the respective combustion-chamber geometry.
   - ✓ Fuel injectors are basically a nozzle with a valve attached, the nozzle creates a spray of fuel and air droplets.

The injection pressure, the degree of atomisation and the shape of the fuel spray jets must be optimally matched to the combustion-chamber shape.

The injection nozzles influence:

- ✓ Mixture formation and combustion sequence
- ✓ Engine power
- ✓ Exhaust-gas behaviour
- ✓ Combustion noises

There are two types of injector:Mechanical types fuel injector and electrical fuel injector

Injectors - mechanical type

Operation:

Fuel is delivered to the high-pressure connection at the commencement of injection. The pressure acts against the injector spring pressure and lifts the needle from its seat. Atomized fuel is sprayed from the nozzle into the engine swirl or combustion chamber.

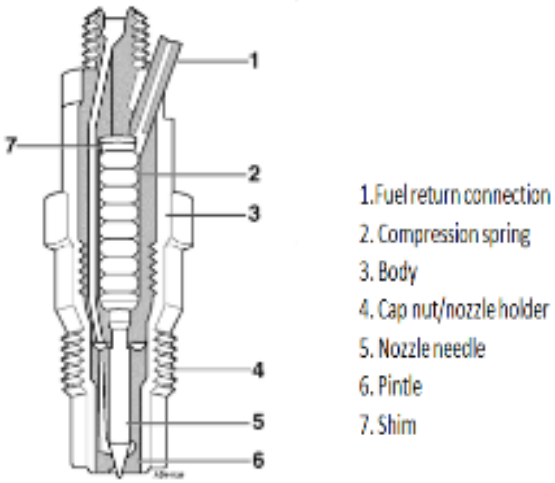


Figure 65 Diesel fuel injector

Injectors - electrical type

Operation

- ✓ Electronically controlled injectors are supplied with a constant supply of fuel at high pressure. A solenoid operated ball-type valve separates the control chamber from the return circuit and ensures that the needle is held on its seat by the injector spring.
- ✓ At the commencement of injection the solenoid is energised and the ball valve opens allowing the pressure in the control chamber to fall. The pressure in the pressure chamber acts against the injector spring and lifts the needle from its seat. Atomized fuel is sprayed from the nozzle into the engine combustion chamber.
- ✓ To reduce the high current required to operate the injector, the engine control module (ECM) rapidly switches the solenoid during the opening duration.

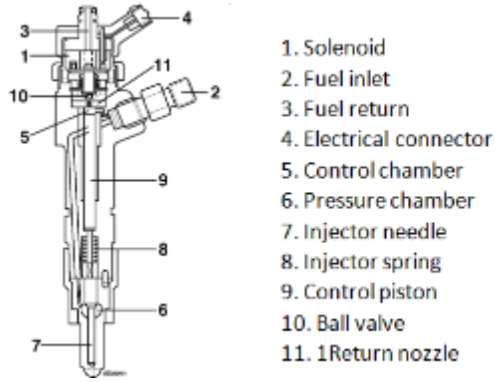


Figure 66 electrical fuel injector

6. Rail

This is a thick walled steel pipe with connections for fuel lines, the pressure sensor, and if necessary the pressure control valve and pressure limiter.

The rail is a pressure reservoir downstream of the high pressure pump. It forms a reserve of diesel under high pressure ready to be used by the injectors.

The rail assembly is made up of the following:

a. Rail:

Stores pressurized fuel that has been pumped from the supply pump and distributes the fuel to each cylinder injector.

b. Rail pressure limiter:

The rail pressure control limiter opens to release the pressure if abnormally high pressure is generated. If pressure within the rail becomes abnormally high, the pressure limiter operates (opens). It resumes operation (closes) after the pressure falls to a certain level. Fuel released by the pressure limiter returns to the fuel tank.

c. Rail pressure sensor

The pressure sensor is essentially made up of a metallic membrane that deforms under pressure.The membrane has a fitted piezo-resistant element whose resistance varies in relation to membrane deformation. This deformation thus represents the amount of pressure in the rail.

The sensor is screwed to the rail. A soft steel washer ensures sealing at high pressure. Using a pre-defined torque and angle that makes the best use of the axial force ensures complete sealing.

The latest versions do not use a sealing washer.

d. The pressure control valve

The pressure control valve controls the fuel pressure in the rail. When rail fuel pressure exceeds the target injection pressure, or when the engine ECU judges that rail fuel pressure exceeds the target value, the pressure discharge valve solenoid coil is energized. This opens the pressure discharge valve passage, allowing fuel to leak back to the fuel tank, and reducing rail fuel pressure to the target pressure.

7. Sensors

Input: Sensors record and transmit information in the form of electrical voltage signals to the ECU.

These record the operating data, such as load, engine speed, engine temperature, boost pressure, and environmental conditions, e.g. intake-air temperature and air pressure.

8. Actuators

Output: The relevant actuators, e.g. the fuel injectors, are supplied with power by the ECU. The desired system operating state is established.

These allow interventions to be made in the fuel-injection system and if necessary in the exhaust-gas recirculation and supercharging systems.

9. Injection pumps:

These systems must fulfil the following functions:

- ✓ Provide the necessary pressure,
- ✓ Inject the necessary amount of fuel (fuel-delivery control),
- ✓ Set the necessary start of injection (start-of-injection control).

As in the passenger vehicle sector, mechanically controlled inline and distributor-type injection pumps have been replaced almost completely by map-controlled fuel injection systems in the heavy goods

vehicle sector as well. They inject at increasingly higher pressures and with increasingly greater accuracy and thereby comply with the stricter emissions thresholds. Mechanically controlled injection pumps cannot meet the demands set.

A difference is made between the following fuel injection systems:

- ✓ Inline injection pumps
- ✓ Distributor-type injection pumps as reciprocating plunger or radial plunger injection pumps with solenoid valve control
- ✓ Unit pump system (ups)
- ✓ Unit injector systems with solenoid valve control (UIS)
- ✓ Common rail injection with solenoid valve controlled injectors
- ✓ High pressure pump

1. In- line injection pump

Injection system with inline injection pump components that belong to a fuel system with inline injection pump are: fuel primer pump, fuel filter with fuel heater if necessary and high pressure equipment. This comprises injection pump, high pressure injector lines, nozzle holders with injection nozzles and return line.

Functions:

- Generate the required injection pressure required
- Meter the injection quantity exactly according to the accelerator pedal position
- Adapt the injection point to the engine speed
- Regulate idling speed and maximum speed

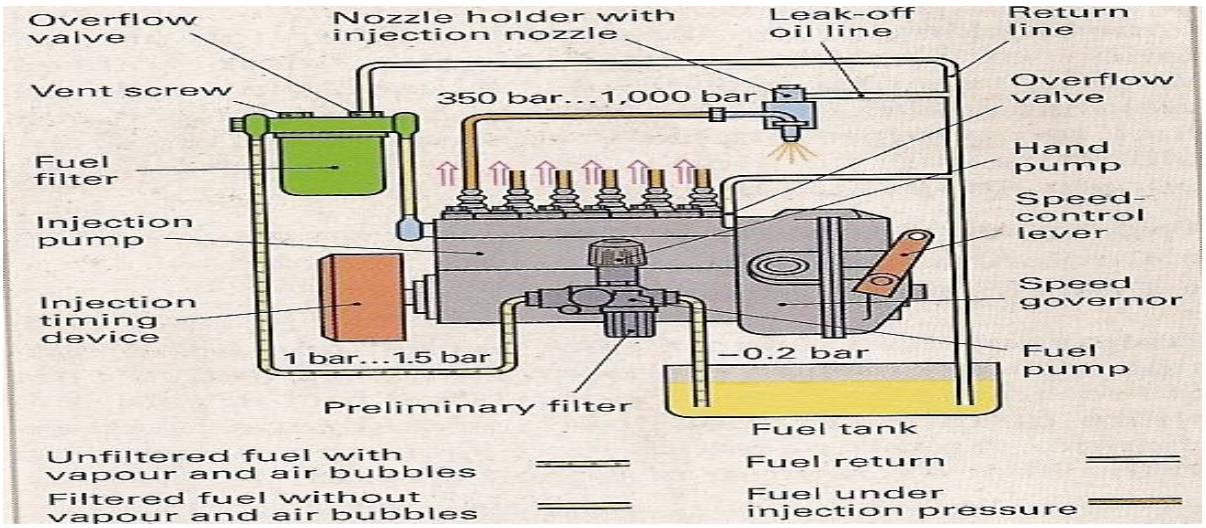


Figure 67 inline fuel supply system

2. Distributor pump

There are two main types of pump used: rotary and axial plunger distributor pump

Axial-piston distributor pump with mechanical control

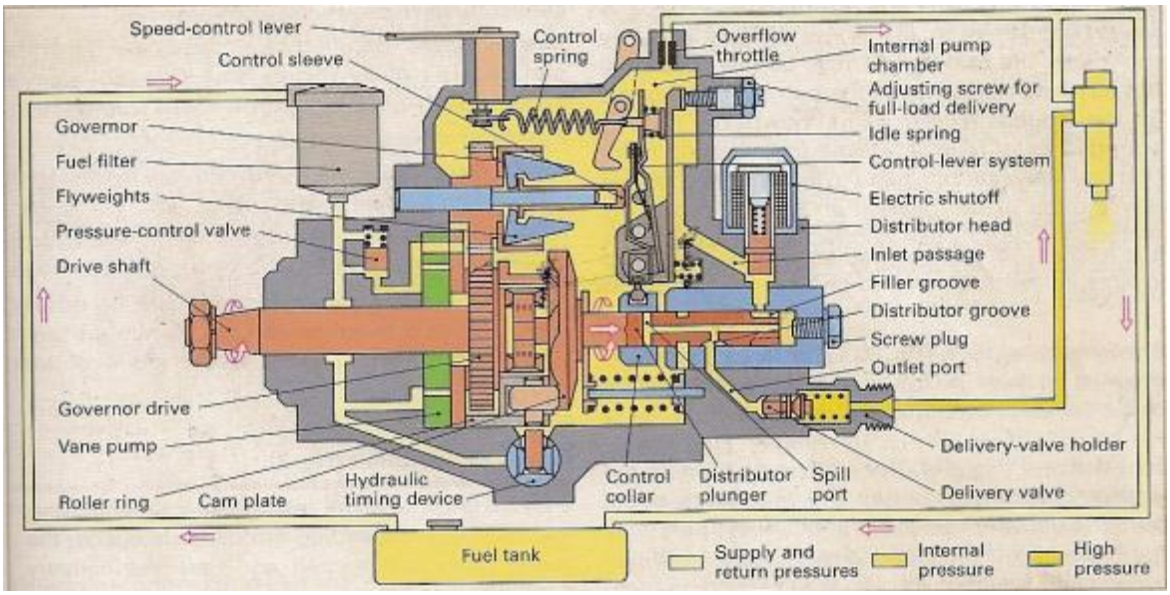


Figure 68 axial piston sistributor pump with mechanical control

Axial piston distributor pump with electronic diesel control

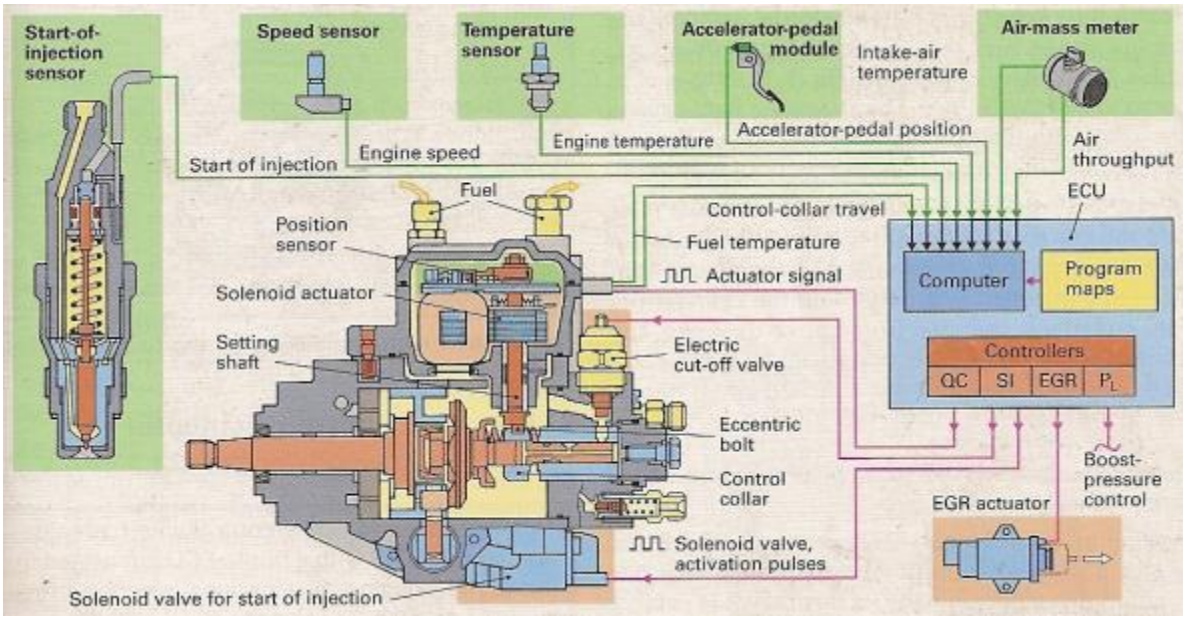


Figure 69 Axial piston distributor pump with electronic diesel control

a) Radial piston distributor injection pump VP44

This is an electronically controllable fuel-injection pump (EDC) with a pump ECU integrated in the pump housing. It generates injection pressures up to 1,900 bar and can be installed in any position.

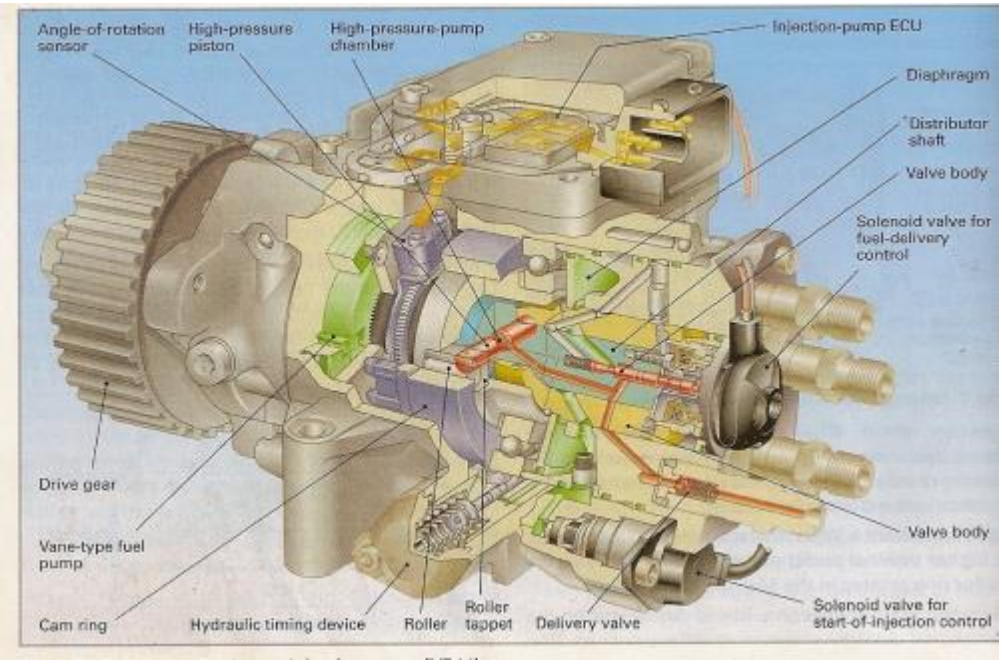


Figure 70 Radial piston distributor injection pump VP44

3.Unit pump system (ups)

This is an electronically controlled fuel-injection system in which each engine cylinder has a unit-injector element in its cylinder head. These injector elements allow top injection pressures up to 2,200 bars.

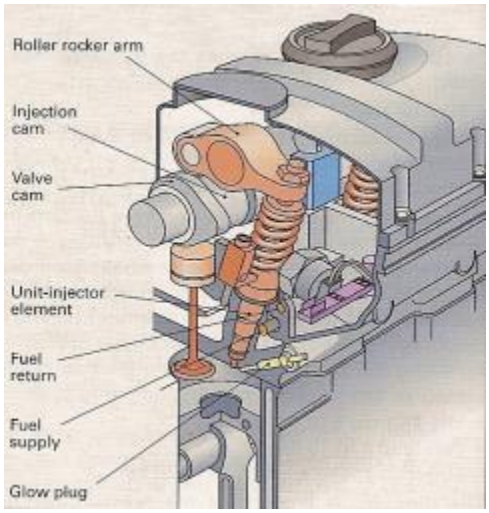


Figure 71 unit pump system (ups)

4.Common rail system High pressure pump

In a common-rail system the fuel is accumulated in a fuel rail under high pressure and injected into the combustion chambers under map- controlled conditions via solenoid valves on the injectors. The injection pressure is generated by the high- pressure pump as a function of engine speed and accumulated in as an accumulator injection system.

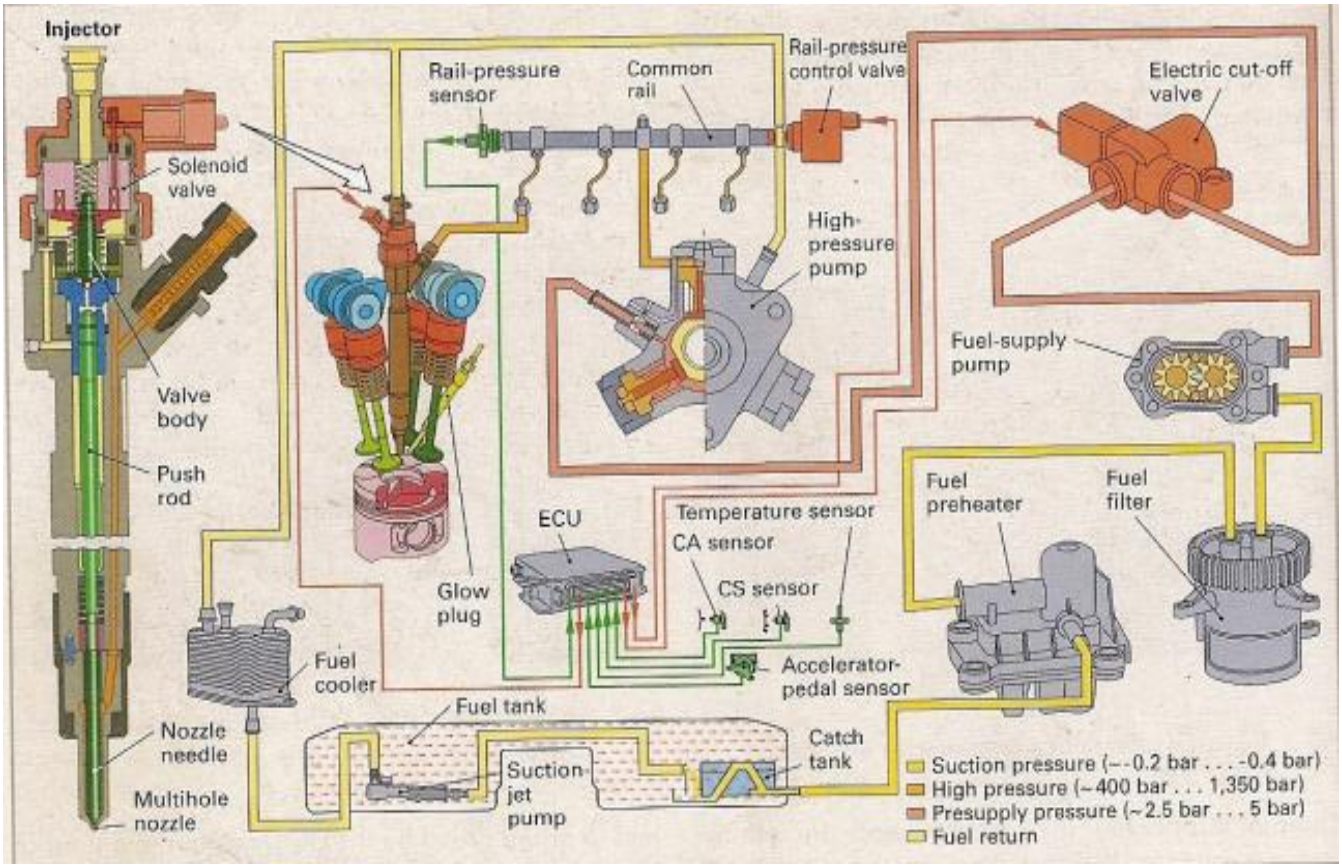


Figure 72 common rail system

Learning Unit 2 – Describe fuel supply main components

LO 2.1 – Describe fuel tank

✓ Content/Topic 1 Description of fuel tank

Fuel tank:

Definition

- Petrol is stored in a fuel tank, which is usually made of plastic or steel. Various hoses are connected to this tank.

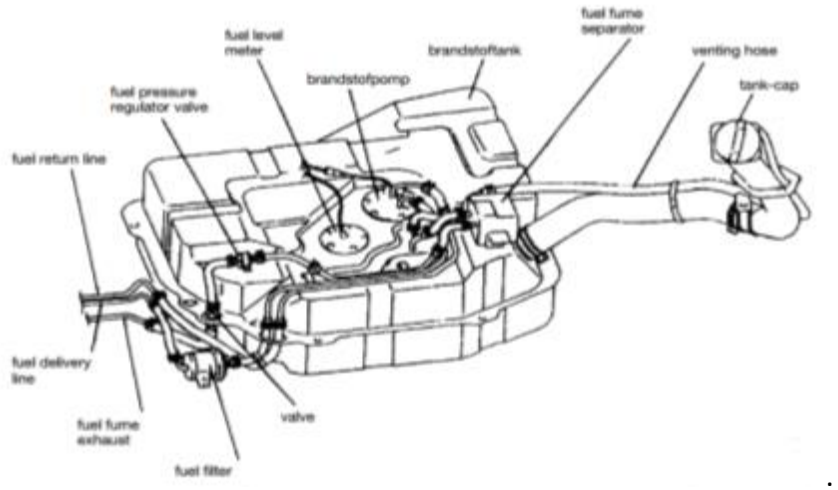


Figure 73 fuel tank

Purpose

- ✓ The fuel tank functions as a storage place for fuel.
- ✓ There are hoses for filling and delivering fuel to the engine, but also venting and ventilating the tank, as well as discharging petrol fumes.

Characteristics

- ✓ For safety reasons, the fuel tank is not situated near the engine or in the crushable zone. Fuel tanks are usually made from plastic or steel. Plastic tanks are easy to make in any desired form and have small mass.
- ✓ Often, a drain plug is mounted in the lowest point of the fuel tank in order to drain fuel and any water that may have collected in the tank.
- ✓ Fuel tanks are equipped with a system for venting and ventilation.
- ✓ Venting air prevents excess pressure from developing when the fuel level rises (for example when filling or when the fuel expands due increases in temperature).
- ✓ Feeding air in is necessary to prevent the possibility that an under pressure in the tank is generated when the fuel level drops.

- ✓ If no air can enter the tank, the under pressure could become so great that the outside air pressure would squash the tank. Under pressure in the tank also inhibits fuel flow.
- ✓ The engine would begin to miss or even stall due to a lack of fuel.
- ✓ The venting/ventilation system is equipped with a roll-over valve.
- ✓ This prevents fuel from spilling out of the tank when the car is on a slope

Filler opening

The filler opening can include provisions to prevent the wrong type of fuel from being used during refuelling.

According to EU guidelines, no more than 30 grams of petrol per minute may overflow the top of the tank. To meet this requirement, automobiles are equipped with safety valves (roll-over valves).

The principle of this valve is based on the rolling movement of a ball, which is used to close the valve.

Fuel level sensor

A sensor to measure fuel level is mounted in the fuel tank. This sensor is a variable resistor that activates the fuel level indicator. The indicator in figure 37 is equipped with two coils (1) and (2).

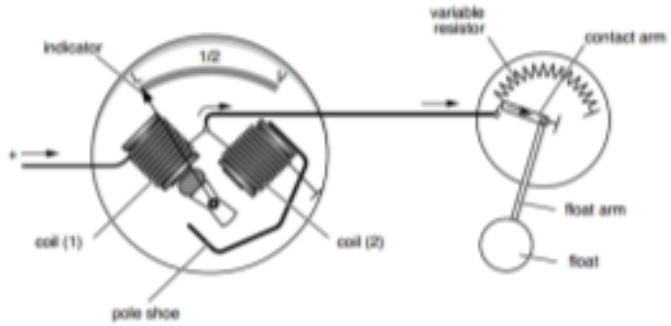


Figure 74 fuel level sensor

When there is little fuel in the tank, the float is in a low position. Most of the electrical current flows through coil (1) and the contact arm to earth. Only a small amount of current flows through coil (2). As a result, coil (1) generates a stronger magnetic field than coil (2), pulling the indicator to the left. The indicator shows the level as low. Metering system with coils: little fuel in the tank

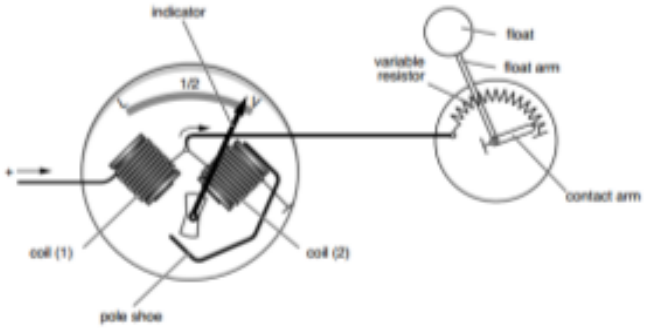


Figure 75 fuel level sensor when little fuel in the tank

The current through coil (2) is relatively small because, in comparison with the circuit through the contact arm, coil (2) has greater resistance. When there is a lot of fuel in the tank, the float is in a high position

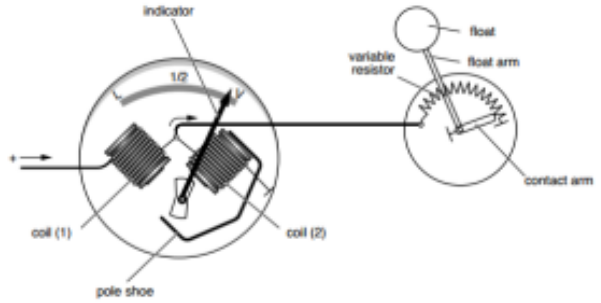


Figure 76 fuel level sensor when there is lot of fuel in the tank

Metering system with a bimetal strip

A great deal of **the variable resistor** is incorporated in the contact-arm circuit, causing this circuit to have relatively high resistance. More current now flows through coil (2), increase the magnetic field generated by coil (2) and, in turn, pulling the indicator to the right. The indicator shows the level as high. Coil (2) is equipped with a pole shoe to intensify the magnetic field from coil (2).This causes the same current to generate a stronger magnetic field in coil (2) than it does in coil (1). The device in figure 39 is equipped with a bimetal strip.

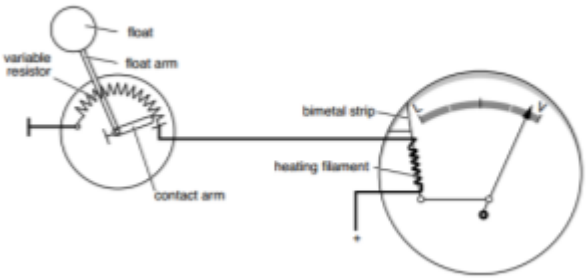


Figure 77 fuel level gauge metering system with bimetal strip

When there is a lot of fuel in the tank, the float is in a high position. The electrical current flows from the plus sign through a small portion of the

Variable resistor and the float arm to earth: Since only a small part of the variable resistor is involved, the current is relatively large. The bimetal strip is strongly heated by the heating filament and is consequently significantly bent; causing the indicator needle to show that there is a lot of fuel in the tank.

When the tank is nearly empty, the float is in a low position. Nearly all the variable resistor is included in the circuit. A relatively small amount of current flows through the heating filament, The bimetal strip is only slightly bent, and the indicator needle shows that there is just a little fuel in the tank.

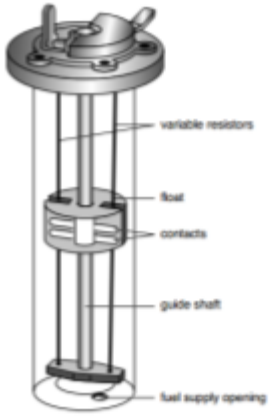


Figure 78 Tank sensor with a vertically moveable float

Fuel-delivery modules

The fuel-delivery components are combined in fuel-delivery modules, which are installed in the fuel tank.

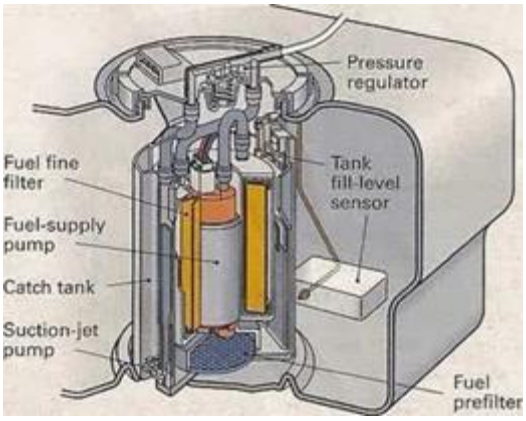


Figure 79 fuel delivery module

Petrol fume collector systems/fuel tank ventilation

Petrol fume collector systems must prevent petrol fumes from entering the environment. When the engine is off, the petrol fumes are stored in the active carbon filter. In a running engine, fumes are fed into the engine intake, depending on operating conditions. Fresh outside air is also fed through the active carbon filter. The channelling of petrol fumes to the intake is regulated by a valve: the **venting control valve.** The venting control valve is activated by the electronic control unit. The precise operation of the fuel fume collector system can vary for each make and type of motor vehicle.

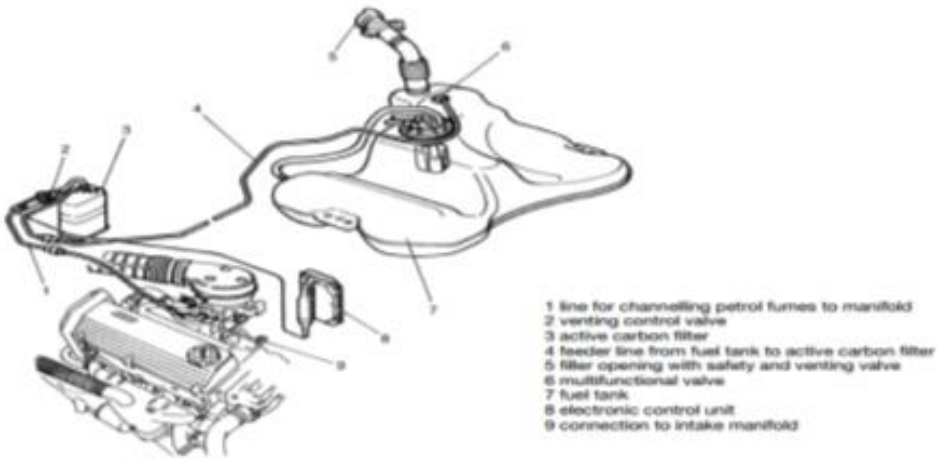


Figure 80 petrol fuel ventilation

When the engine is idling, the main vent is closed by the venting control valve. A small amount of petrol fumes flow through the constricted vent opening to the engine air intake. The venting control valve is opened under partial load. Petrol fumes flow through the main vent and the constricted vent opening to the engine air intake.

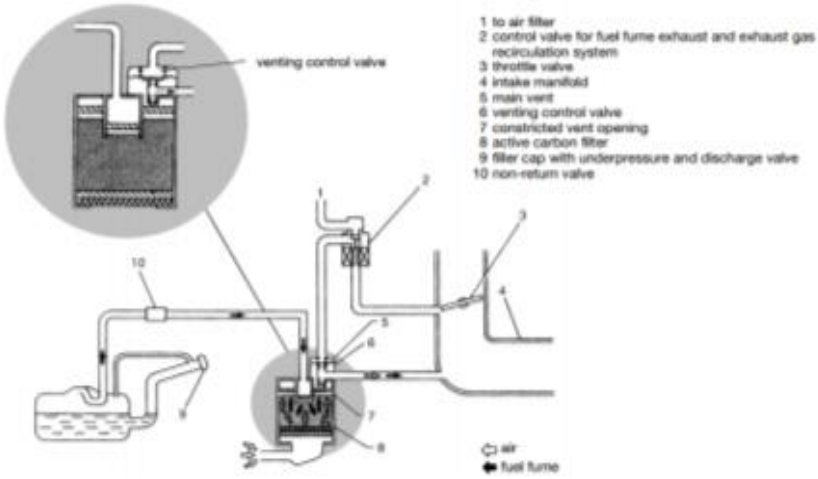


Figure 81 carbon canister system

- ✓ The opening of the venting control valve occurs by a vacuum governed by the **control valve** for the fuel fume exhaust and exhaust gas recirculation system. The control valve for the fuel fume exhaust and exhaust gas recirculation system is activated by the engine's electronic control unit.
- ✓ The non-return valve must prevent liquid petrol from coming in contact with active carbon filter. The non-return valve has, however, to permit air to pass from the active carbon filter to the petrol tank.

LO 2.2 – Describe fuel lines

✓ **Content/Topic 1 Description of fuel lines**

Fuel line:

Definition

The components of the fuel system are connected to each other by lines. It may be fuel supply line or return line. Steel line and flexible hoses carry fuel from the tank to the engine.

Purpose

The fuel lines connect all of the various fuel supply components.

Characteristics

- ✓ These can be made of steel, rubber or plastic.
- ✓ The material of the lines may not be affected by the fuel.
- ✓ Rubber and plastic lines can become hard and porous with age, and leaks may result.
- ✓ Fuel lines must be routed in such a way that they are protected from mechanical damage and heat. If the lines become too warm, vapour bubbles can occur in the fuel.

It is important when laying fuel lines to ensure that:

- ✓ They are able to withstand the torsion of the vehicle and the movements of the engine.
- ✓ They are protected against mechanical damage.
- ✓ The lines are not routed past hot parts - in order to avoid vapour-bubble formation.
- ✓ They are where possible laid in a steadily rising direction so that vapour bubbles can be quickly removed from the system.
- ✓ No fuel vapours can collect in the vehicle in the event of leaks.

LO 2.3 – Describe fuel filter

✓ Content/Topic 1 description of fuel filter

Fuel filter:

Definition

- ✓ Since fuel may contain dirt and water particles that impede proper functioning of the system, Fuel filters are installed to remove dirt and water content from the fuel.
- ✓ Once the fuel leaves the pump, it flows through the fuel filter and any impurities are trapped in the filter.

Figure 83 fuel filter

Purpose

The fuel filter removes dust and moisture contained in the fuel to protect the engine's injection pump and nozzle from wear and clogging.

Characteristics

- ✓ The filter can be mounted either under the vehicle or in the engine compartment.
- ✓ Water trapped in the filter can freeze in winter (especially in filters mounted underneath). The filter must therefore be periodically replaced.
- ✓ There is an arrow on the filter housing to indicate the direction of fuel flow.

How foreign matter in fuel can affect your engine:

Causes	Effects	Engine Condition
✓ Dust ✓ Moisture	✓ Wearing and clogging of injection pump and nozzle ✓ Rust ✓ Moisture freezes	✓ Loss of output ✓ Bad fuel economy

Fuel is sent from the fuel tank to the engine by suction produced at the feed pump. The fuel pump is located in this circuit. Fuel passes through the filter's inlet, enters the filter case, and then passes through the filter medium where foreign matter is removed.

Filter (filter medium): This removes dust and moisture from the fuel.

Gasket: This provides a seal to prevent fuel from leaking at the joints.

Spring: This holds the filter firmly in place in its case.

Filter types & features

1.There are two types of fuel filters depending on how they are attached during replacement: spin-on filters and cartridge filters.

a) Spin-on Filters

The filter medium is contained in a metal case which is threaded on the bottom. This type offers excellent workability as the entire case can be replaced.

Figure 84 spin on filter

b) Cartridge Filters

Only the filter medium is replaced, so this helps reduce the amount of waste material produced per replacement.

Figure 85 cartidge filter

2) A main filter and pre-filter are used depending on how the fuel circuit is configured.

Main Filter Negative Pressure:

The main filter is primarily responsible for capturing fine contaminants. Negative pressure types utilize the suction pressure created by the feed pump, and are placed closer to the fuel tank than the feed pump.

Main Filter Positive Pressure:

Positive pressure filters utilize the up thrust pressure from the feed pump, and are located closer to the engine than the feed pump. Some vehicles may be equipped with both negative and positive pressure main filters.

Pre-Filter:

The pre-filter removes relatively large pieces of contaminants and moisture contained in the fuel. These are installed on the circuit, close to the fuel tank.

LO 2.4 – Describe delivery pump

- ✓ **Content /Topic1 description of delivery pump**

Delivery pump

Definition

A fuel pump is a component in motor vehicles that transfers liquid from the from the fuel tank to the carburettor of the internal combustion engine. Carburated engine often use low pressure mechanical pumps that are mounted outside the fuel tank, whereas fuel injected engine often use electric fuel that are mounted inside the fuel tank (and some fuel injected engine have two fuel pumps, one low pressure/high volume supply in the tank and one high pressure/ low volume pump on or near engine.

Purpose

- ✓ The pump creates a higher pressure in the fuel lines, pushing the fuel to the engine.
- ✓ In most cars, the fuel pump delivers a constant flow of fuel to the engine; fuel not used is returned to the tank.

Characteristics

There are two main types of fuel pumps:

1. **Mechanical fuel pump**
   Petrol engines with carburettors are often equipped with mechanically operated fuel pumps.

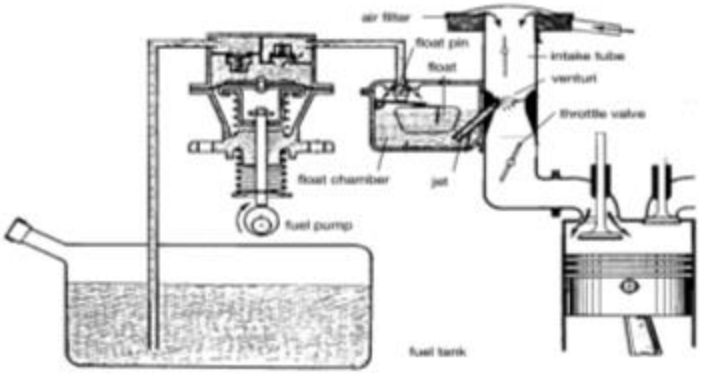


Figure 86 mechanical fuel pump

This fuel pump is a diaphragm pump mounted on the engine block. Mechanically-operated fuel pumps are usually driven by the engine camshaft. Figure shows the pump during the suction stroke. When the diaphragm (4) is pushed down by the pump rocker arm (1) and pushrod (2), the volume above the diaphragm increases, decreasing the pressure in the chamber about the diaphragm, creating an under pressure. Because the fuel in the tank is under atmospheric pressure, fuel is forced out of the tank through the suction valve (5) to the pump.

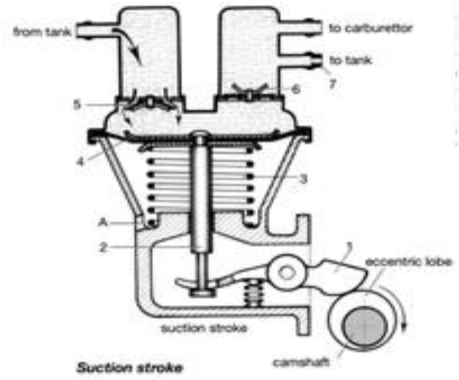


Figure 87 mechanical fuel pump in suction stroke

- ✓ Figure shows the pump during the pressure stroke. As the eccentric lobe passes by the rocker arm (1), the spring (3) is able to push the diaphragm (4) back up.
- ✓ The suction valve (5) is pressed against the valve seat and the fuel is pushed through the pressure valve (6) to the carburettor.
- ✓ Excess fuel flows through the flow restrictor (7) back to the tank.
- ✓ A thick plastic gasket is inserted between the fuel pump and the engine block (or cylinder head). This gasket protects the pump from engine heat, preventing vapour bubbles from forming in the pump.
- ✓ Ruptures in the gasket between the engine block and the fuel pump can result in lubrication leakages.

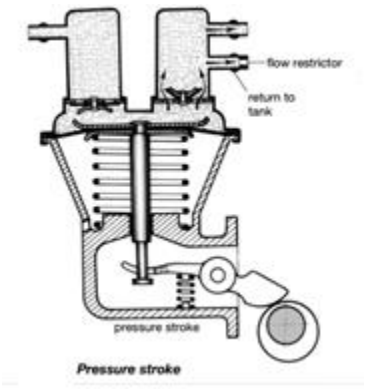


Figure 88 mechinical fuel pump in delivery stroke

2. Electric fuel pump

The fuel pump is electrically powered. The pump and the electric motor are placed in housing and submerged in petrol. The petrol cools the electric motor. Because no combustible mixture is present, there is no danger of ignition. A sieve is mounted in front of the pump's suction line. This

Prevents coarse impurities from entering the pump, one frequently used type of pump is the roller pump

Design:

The pump consists of a rotor (2) with grooves containing rollers (3). The rotor is in an eccentric position in terms of the pump housing. When the rotor rotates, centrifugal force causes the rollers (3) to be pressed against the inner wall of the pump housing (4).

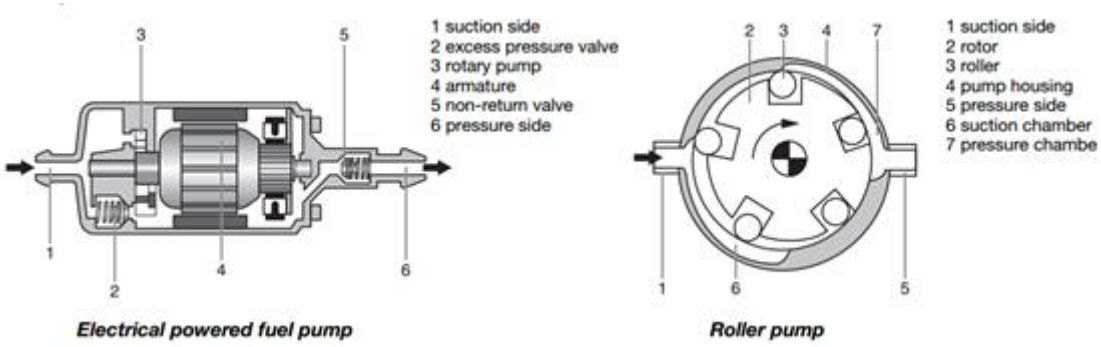


Figure 89 electric fuel pump

Operation

- ✓ When a roller passes the suction chamber (6), the space behind the roller becomes increasingly larger, creating an under pressure in the suction chamber that causes fuel to flow into it. This fuel is transported by the following roller to the pressure chamber (7). From the pressure chamber, the fuel is delivered through the fuel lines to the engine. The pressure generated by the fuel pump is 6 bar (600 kPa) or more.
- ✓ A non-return valve is mounted in the pump's delivery line to prevent the fuel line from running dry when the pump stops.
- ✓ The pump rotates a constant speed, while the quantity of fuel delivered depends on engine requirements. An overpressure valve is installed to prevent pump pressure from becoming too high

LO 2.5 – Describe injection supply system

- **Content/Topic 1 Differentiation of injection supply system**

Fuel injection is the introduction of fuel in an internal combustion engine by using an injector.

All compression ignition (diesel) engine use fuel injection and many spark ignition engine use fuel injection of one kind or another.

There are two Types of injection:

- ✓ Diesel injection
- ✓ Petrol injection

1. Petrol injection system

The petrol system now comes to modern vehicle. The fuel is atomized by means of an injector nozzle then delivered into an air stream. There may be separate fuel injector are used for separate cylinder or one single fuel injector.

Advantages

- ✓ This is the most accurate fuel supply system
- ✓ High power is developed
- ✓ It has quick starting and warm up
- ✓ Low specific fuel consumption

Disadvantages

- ✓ Back flow of petrol may take place
- ✓ High initial cost

For this purpose, the system must...

- ✓ Store fuel in the fuel tank.
- ✓ Deliver bubble-free fuel.
- ✓ Filter fuel.
- ✓ Generate fuel pressure and keep it constant.
- ✓ Return excess fuel.
- ✓ Prevent fuel vapors from escaping.

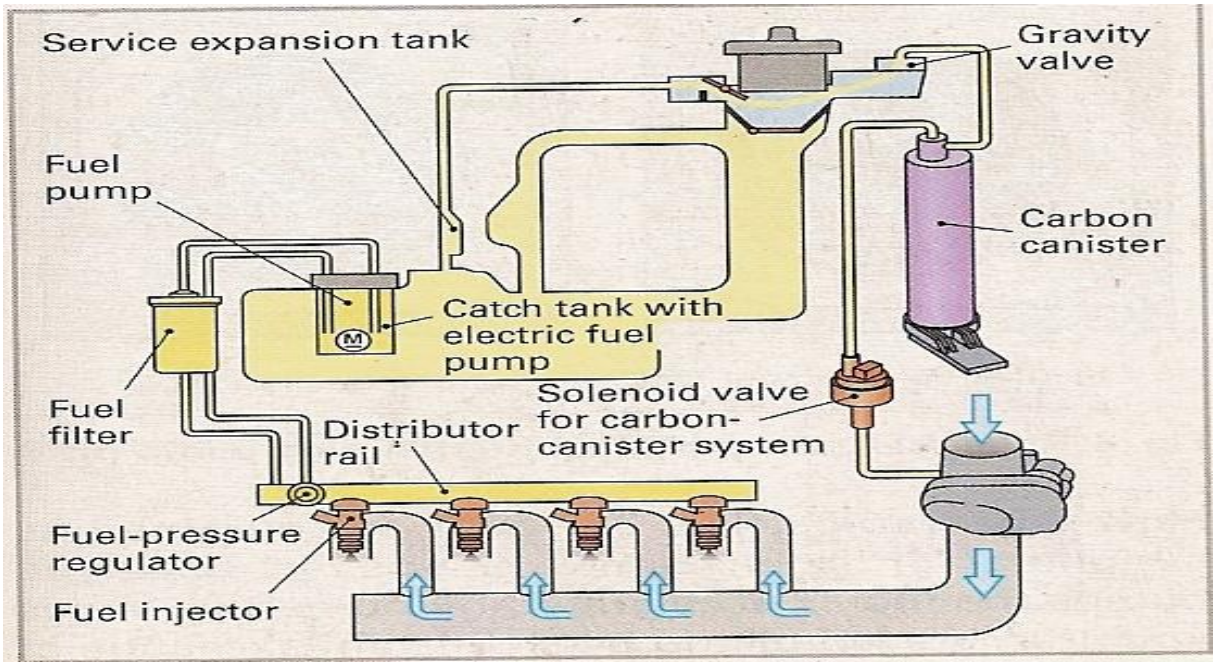


Figure 89 petrol fuel supply system

2. Diesel injection system

The fuel injection lies at the heart of diesel engine. By pressurising and injecting the fuel, the system forces it the air that has been compressed to high pressure in the combustion chamber.

The diesel fuel injection system consists of:

- ✓ Fuel injection pump: pressurises fuel high pressure
- ✓ High pressure pipe: sends fuel to the injection nozzle
- ✓ Injection nozzle: injects the fuel into the cylinder
- ✓ Feed pump: sucks fuel from the fuel tank
- ✓ Fuel filter: filtrate the fuel

Function of fuel injection system

(I) To inject the correct amount of fuel required by engine speed and load,
(ii) To maintain correct timing for beginning and end of injection,
(iii) To inject the fuel into the combustion space against high compression pressure.
(iv) To atomize the fuel for quick ignition.
(v) To provide the necessary pressure
(vi) To set the necessary start of injection.

Fuel supply system is a separate system used to deliver diesel at correct time in correct quantity, to a diesel engine (or C.I engine), for smooth and efficient operation. The operation of a diesel engine is different from that of a petrol engine. In a petrol engine, air fuel mixture is supplied by a carburetor to the engine, at the beginning of the suction stroke. But in a diesel engine, fuel (without air) is

supplied at the end of the compression stroke, by means of a fuel supply system.

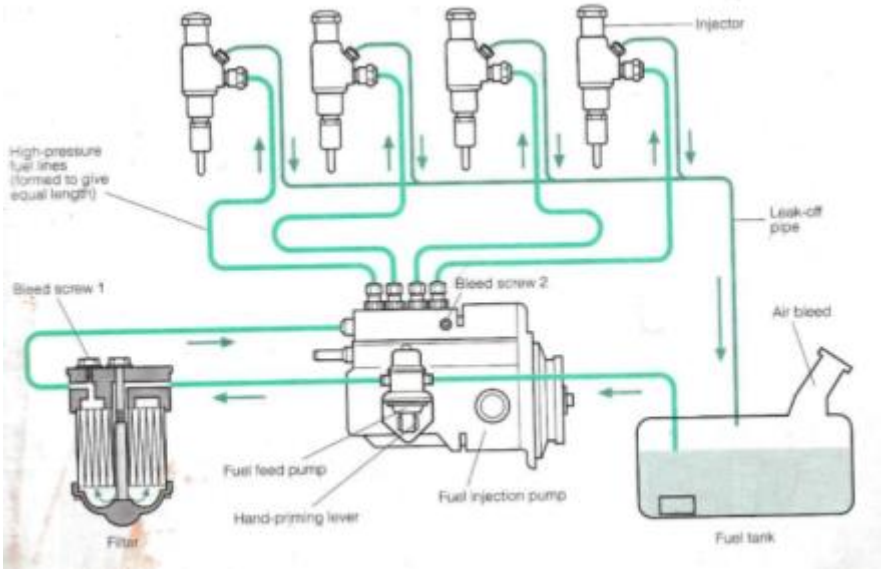


Figure 90 diesel fuel supply system

Ignition lag in a diesel engine:

The period of time required for internal mixture formation up to the initiation of combustion is called the ignition lag. The ignition lag is the period of time between the start of injection and the initiation of combustion.

Excessive particle emissions (soot production) are often caused by among others the following:

- ✓ Engine when cold starting or warming up
- ✓ Engine in full-load operation
- ✓ Clogged air filter
- ✓ Defective injection nozzle
- ✓ Faults in the combustion chamber or in the intake system

Excessive ignition lag is often caused by among others the following:

- ✓ Cold engine and thus high heat losses
- ✓ Over-advanced start of injection
- ✓ Poor fuel quality (cetane number too low)
- ✓ Deficient compression
- ✓ Dribbling injection nozzles

There are basically two different injection processes used in diesel engines:

- ✓ **Direct injection** into an undivided combustion: chamber **(DI)**
- ✓ **Indirect injection** into the secondary chamber of a divided combustion chamber **(IDI)**

Indirect-injection diesel engines: Two different processes may be used, based on the shape of the secondary chamber: **pre-chamber** and **whirl-chamber process.**

Learning Unit 3 – Maintain fuel supply system

LO 3.1 – Select tools, materials and equipment

✓ **Content/Topic1 Selection of required hand tools**

Hand tools selection

A.Hand tools

Most service procedures require the use of hand tools. Therefore, technicians need a wide assortment of these tools. Each has a specific job and should be used in a specific way. Most service departments and garages require their technicians to buy their own hand tools.

A1. Wrenches

The word wrench means twist. A wrench is a tool for twisting and/or holding bolt heads or nuts. Nearly all bolt heads and nuts have six sides; the jaw of a wrench fits around these sides to turn the bolt or nut. All technicians should have a complete collection of wrenches. This includes both metric and SAE wrenches in a variety of sizes and styles

Figure 91 wrench spanners

The following is a brief discussion of the types of wrenches used by automotive technicians.

A.1.1.Open-End Wrench The jaws of the open-end wrench allow the wrench to slide around two sides of a bolt or nut head where there might be insufficient clearance above or on one side of the nut to accept a box wrench.

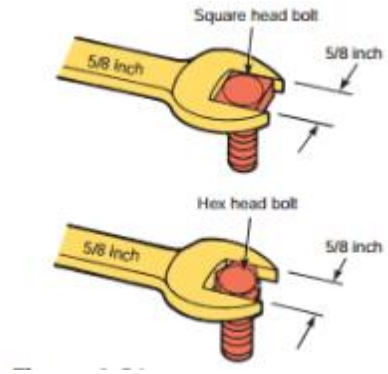


Figure 92 open end wrench spanner

A1.2.Box-End Wrench The end of the box-end wrench is boxed or closed rather than open. The jaws of the wrench fit completely around a bolt or nut, gripping each point on the fastener. The box-end wrench is not likely to slip off a nut or bolt. It is safer than an open-end wrench. Box-end wrenches are available as 6 point and 12 point**)**. The 6-point box end grips the screw more securely than a 12-point box-end wrench can and avoids damage to the bolt head.

Figure 93 box end wrench

A1.3.Allen Wrench Setscrews are used to fasten door handles, instrument panel knobs, engine parts, and even brake callipers. A set of fractional and metric hex head wrenches, or Allen wrenches, should be in every technician's toolbox. An Allen wrench can be L-shaped or can be mounted in a socket driver and used with a ratchet.

Figure 94 allen wrench

A.2.Sockets and Ratchets

A set of Imperial and metric sockets combined with a ratchet handle and a few extensions should be the top side of a socket has a square hole that accepts a square lug on the socket handle.

This square hole is the drive hole. One handle fits all the sockets in a set. On better-quality handles, a spring loaded ball in the square drive lug fits into a depression in the socket. This ball holds the socket to the handle. An assortment of socket (ratchet) handles is shown.

Figure 95 sockets and ratchets

Not all socket handles are ratchet Some are called breaker bars, are simply long arms with a swivel drive used to provide extra torque onto a bolt to help loosen it.

Figure 96 breaker bars

A2.1.Special Sockets Screwdriver and Allen wrench attachments are also available for use with a socket wrench.

Figure 97 special sockets

A.3.Torque Wrenches

Torque wrenches measure how tight a nut or bolt is. Many of a car's nuts and bolts should be tightened to a certain amount and have a torque specification that is expressed in foot-pounds (U.S.)

Figure 98 torque wrench

A.4.Extensions: An extension is commonly used to separate the socket from the ratchet or handle. The extension moves the handle away from the bolt and makes the use of a ratchet more feasible. Extensions are available in all common drive sizes and in a variety of lengths.

Figure 99 extensions

A.5.Screwdrivers

A screwdriver drives a variety of threaded fasteners used in the automotive industry. You also should have an assortment of special screwdrivers, such as those with a head design

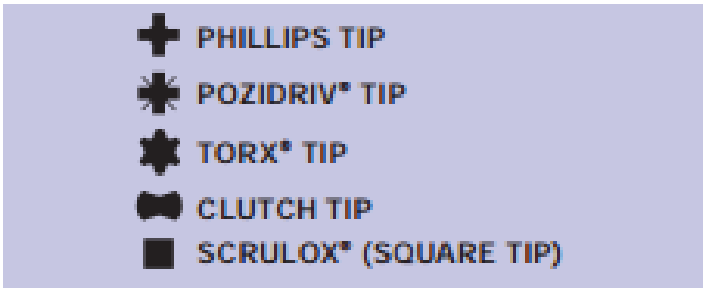


Figure 100 screw driver design

Standard Tip Screwdriver*:* A slotted screw accepts a screwdriver with a standard or blade-type tip. The standard tip screwdriver is probably the most common type It is useful for turning carriage bolts, machine screws, and sheet metal screws. The width and thickness of the blade determine the size of a standard screwdriver. Always use a blade that fills the slot in the fastener.

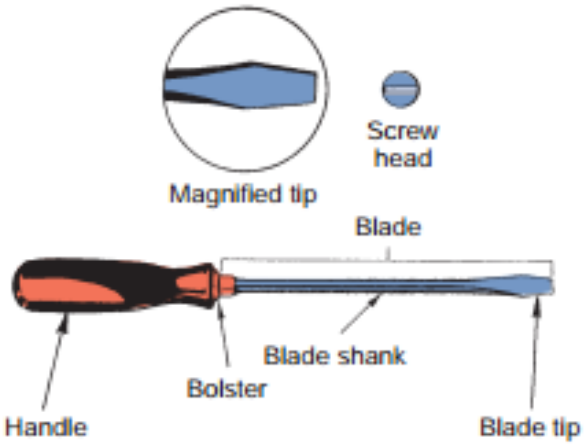


Figure 101 part of screw driver

A.5.3.Impact Screwdriver

An impact screwdriver is used to loosen stubborn screws. Impact screwdrivers have interchangeable heads and bits that allow the handles of the tools to be used with various screw head designs.

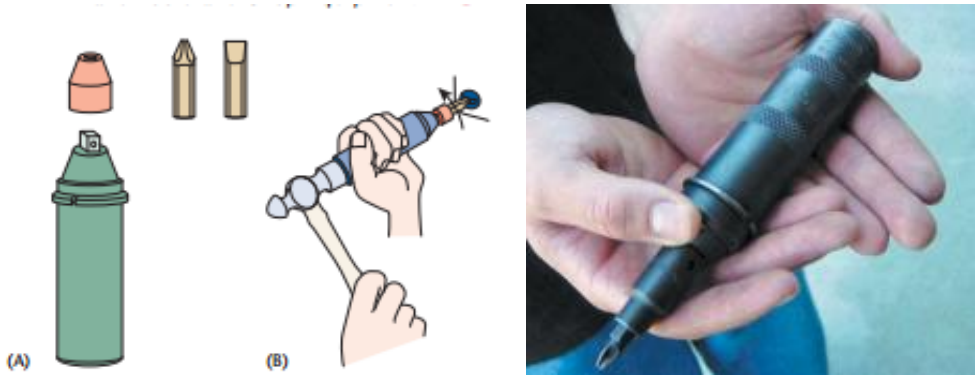


Figure 102 impact screw driver

- ✓ To use an impact screwdriver select the correct bit and insert it into the driver's head. Then hold the bit against the screw slot while firmly twisting the handle in the desired direction. Strike the handle with a hammer. The force of the hammer will exert a downward force on the screw and, at the same time, exert a twisting force on the screw.

A.6.Pliers

Pliers are gripping tools used for working with wires, clips, and pins. At a minimum, an auto technician should own several types: standard pliers for common parts and wires, needle nose for small parts, and large, adjustable pliers for large items and heavy-duty work.

Figure 103 different types of pliers

A brief discussion on the different types of pliers follows:

A.6.1. ***Combination pliers*** are the most common type of pliers and are frequently used in many kinds of automotive repair. The jaws have both flat and curved surfaces for holding flat or round objects. Also called slip-joint pliers, the combination pliers have many jaw-opening sizes. One jaw can be moved up or down on a pin attached to the other jaw to change the size of the opening.

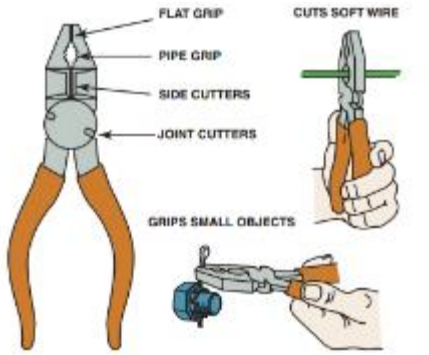


Figure 104 combination plier

A.6.2. Adjustable pliers*,* commonly called *channel locks,* have a multi-position slip joint that allows for many jaw-opening sizes.

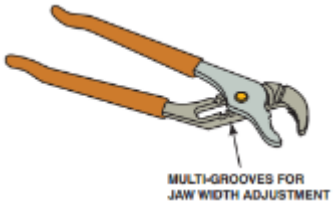


Figure 105 adjustable plier

A.6.3.Needle nose pliers

They have long, tapered jaws. They are great for holding small parts or for reaching into tight spots. Many needle nose pliers also have wire-cutting edges and a wire stripper. Curved needle nose pliers allow you to work on a small object around a corner.

Figure 107 Needle nose pliers

A.6.4.Locking pliers, or vise grips, are similar to the standard pliers, except they can be tightly locked around an object. They are extremely useful for holding parts together. They are also useful for getting a firm grip on a badly rounded fastener that is impossible to turn with a wrench or socket. Locking pliers come in several sizes and jaw configurations for use in many auto repair jobs.

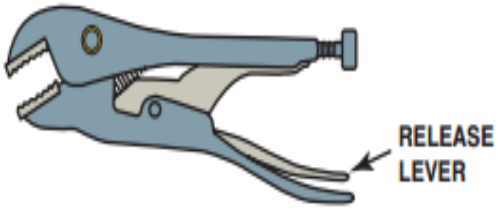


Figure 108 Locking pliers, or vise grips

A.6.5. Snap- or lock ring pliers are made with a linkage that allows the movable jaw to stay parallel throughout the range of opening. The jaw surface is usually notched or toothed to prevent slipping.

Figure 109 Snap- or lock ring pliers

A.6.6.Retaining ring pliers are identified by their pointed tips that fit into holes in retaining rings. Retaining ring pliers come in fixed sizes but are also available in sets with interchangeable jaws.

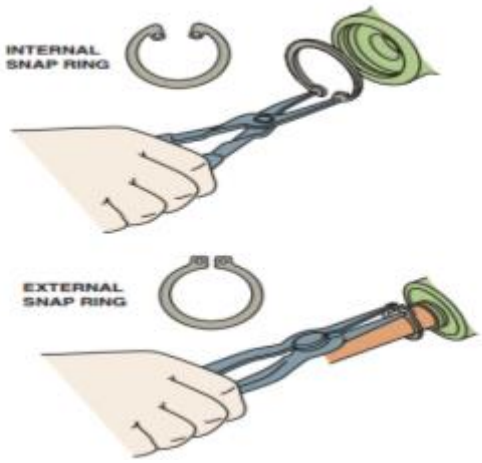


Figure 110 Retaining ring pliers

A.7.Hammers

Hammers are identified by the material and weight of the head. There are two groups of hammer heads, steel and soft faced your tool set should include at least three hammers: two

A.7.1.ball-peen hammers,

The heads of steel-faced hammers are made from high-grade alloy steel. The steel is deep forged and heat treated to a suitable degree of hardness.

Figure 111 ball pein hammer

A.7.2.Soft Hammer

Soft-faced hammers have a surface that yields when it strikes an object. Soft-faced hammers should be used on machined surfaces and when marring a finish is undesirable. For example, a brass hammer should be used to strike gears or shafts because it will not damage them.

Figure 112 soft hammer

A.8.Chisels

Chisels are used to cut metal by driving them with a hammer. Automotive technicians use a variety of chisels for cutting sheet metal, shearing off rivet and bolt heads, splitting rusted nuts, and chipping metal. A variety of chisels are available, each with a specific purpose, including flat, cape, round-nose cape, and diamond point chisels.

✓ Content/Topic 2 Selection of materials to be use in maintenance of fuel supply

Materials: a substance or mixture of substances that constitutes an object. The materials are uniquely used once for particular operation

1. **Sand paper**

   Sandpaper and glass paper are names used for a type of coated abrasive that consists of sheets of paper or cloth with abrasive material glued to one face or smooth surface.

Figure 113 sand paper

2. **Anti-rust**

   Anti-corrosion refers to the protection of metal surfaces from corroding in high-risk (***corrosive***) environments. A ***corrosion*** inhibitor is a chemical compound that, when added to a ***liquid*** or gas, decreases the ***corrosion*** rate of a material,

Figure 114 anti-rust cup

3. **Soaps**

   Soap is a salt of a fatty acid used in a variety of cleansing and lubricating products. In a domestic setting, **soaps** are surfactants usually used for washing, bathing, and other types of housekeeping. In industrial settings, **soaps** are used as thickeners, components of some lubricants, and precursors to catalysts.it can be liquid, powder or bar.

Figure 115 different types of soaps

✓ Content/Topic 3 Selection of equipment for fuel supply maintenance

Equipment selection:

1.Multimeters

A **multimeter** is a must for diagnosing the individual components of an electrical system. Multimeters have different names, depending on what they measure and how they function. A volt-ohm-milliamp meter is referred to as a VOM or DVOM, if it is digital.

A **digital multimeter (DMM)** can measure many more things than volts, ohms, and low current. Most multimeters measure direct current (dc) and alternating current (ac) amperes, volts, and ohms.

Figure 116 digital multi meter

It consists of ammeter, ohmmeter and voltimeter.

a)Ammeter

An **ammeter** measures current flow in a circuit. Current is measured in amperes. Unlike the voltmeter and ohmmeter, the ammeter must be placed into the circuit or in series with the circuit being tested.

- ✓ Normally, this requires disconnecting a wire or connector from a component and connecting the ammeter between the wire or connector and the component.
- ✓ The red lead of the ammeter should always be connected to the side of the connector closest to the positive side of the battery and the black lead should be connected to the other side.

b)Voltmeter

A **voltmeter** has two leads: a red positive lead and a black negative lead. The red lead should be connected

to the positive side of the circuit or component. The black should be connected to ground or to the negative side of the component.

- ✓ Voltmeters should be connected across the circuit being tested. A voltmeter measures the voltage available at anypoint in an electrical system.
- ✓ A voltmeter can also be used to test voltage drop across an electrical circuit,component, switch, or connector. A voltmeter can also be used to check for proper circuit grounding.

c)Ohmmeter

An **ohmmeter** measures resistance to current flow in a circuit. In contrast to the voltmeter, which operates
by the voltage available in the circuit, an ohmmeter is battery powered. The circuit being tested must have
no power applied.

- ✓ If the power is on in the circuit, the ohmmeter will be damaged.The two leads of the ohmmeter are placed across or in parallel with the circuit or component being tested.
- ✓ The red lead is placed on the positive side of the circuit and the black lead is placed on the negative
  side of the circuit.
- ✓ The meter sends current through the component and determines the amount of resistance based on the voltage dropped across the load.
  The scale of an ohmmeter reads from 0 to infinity (∞).
- ✓ A 0 reading means there is no resistance in the circuit and may indicate a short in a component that should show a specific resistance. An infinity reading indicates a number higher than the meter can measure, which usually indicates an open circuit.

2.Hand scanner

A **scanner** 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.

Figure 117 hand scanner

Various scan tool connectors for OBD-II systems.

The scan tool is connected to specific diagnostic connectors on the vehicle. Some manufacturers have one diagnostic connector. This connects the data wire from each computer to a specific terminal in this connector. Other manufacturers have several diagnostic connectors on each vehicle, and each of these connectors may be connected to one or more computers.

Figure 118 scanner connector

The scan tool must be programmed for the model year, make of vehicle, and type of engine. With OBD-II, the diagnostic connectors (commonly called data link connectors, or DLCs) are located in the same place on all vehicles. Also, any scan tool designed for OBD-II will work on all OBD-II systems; therefore, the need to have designated scan tools or cartridges is eliminated.

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. There are many different scan tools available. Some are a combination of other diagnostic tools, such as a lab scope and graphing multimeter.

3.Injector tester

Injection-nozzle test rig

This is used to check removed nozzle-holder assemblies for leaks, opening pressure and spray shape. before using injection nozzle test rig clean nozzle first then carry the test. it can be use for slide test,leak test,chatter test,spray pattern check,...

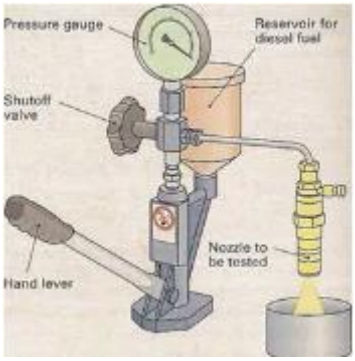


Figure 119 injection tester rig

4.Injection pump tester

Diesel test bench 12psb-d injection pump tester, it is designed as per the fuel injection pump working principle one the engine, with the digital control, it is a must fuel injection calibration machine for diesel pump repair workshop, this diesel pump test bench is used for all types of mechanical fuel pump test.

Figure 120 injection pump bench tester

LO 3.2 – Clean, lubricate and grease performance of fuel supply system

✓ Content/Topic 1 Classification of Cleaning techniques

Cleaning definition

Cleaning is the process of removing unwanted substances, such as dirt, infectious agents, and other impurities, from an object or environment. Cleaning occurs in many different contexts, and uses many different methods and technics.

Types of cleaning techniques

There are three cleaning methods to be used which are wet cleaning, abrasive cleaning and thermal cleaning.

Wet cleaning:

It is Washing, usually done with water and often some kind of soap or detergent Pressure washing, using a high-pressure stream of water. This method of cleaning uses chemical action to remove dirt, grease, scale, paint, and/or rust.

Chemical Cleaning Machines

Parts Washers Parts washers (often called solvent tanks) are one of the most widely used and inexpensive methods of removing grease, oil, and dirt from the metal surfaces of a seemingly infinite variety of automotive components and engine parts. A typical washer setup (Figure 10–25) might consist of a tank to hold a given volume of solvent cleaner and some method of applying the solvent. These methods include soaking, soaking and agitation, solvent streams, and spray gun applicators.

Soak Tanks

There are two types of soak tanks: cold and hot.

Cold soak

Cold soak tanks are commonly used to clean carburetors, throttle bodies, and aluminum parts. A typical cold soak unit consists of a tank to hold the cleaner and a basket to hold the parts to be cleaned. After soaking with or without gentle agitation is complete, the parts are removed, flushed with water, and blown dry with compressed air.

Figure 121 cold soaking cleaning

Hot soak

Hot soak tanks are actually heated cold tanks. The source of heat is electricity, natural gas, or propane. The solution inside the hot tanks usually ranges from 160°F to 200°F (71°C to 93°C). Most tanks are generally large enough to hold an entire engine block and its related parts.

Figure 122 hot soak machine

Hot tanks use a simple immersion process that relies on a heated chemical to lift the grease and grime off the surface. Liquid or parts agitation may also be used to speed up the job. Agitation helps shake the grime loose and also helps the liquid penetrate blind passageways and crevices in the part. Generally speaking, it takes one to several hours to soak most parts clean.

Abrasive cleaning:

- ✓ Abrasive blasting, typically used to remove bulk material from a surface, may be used to remove contaminants as well Dry cleaning of clothing and textiles, using a chemical solvent other than water.
- ✓ Most abrasive cleaning machines are used in conjunction with other cleaning processes rather than as a primary cleaning process itself.

- ✓ Some manual cleaning is inevitable. Heavy build-up of grease and/or carbon should initially be removed by scraping or wire brushing.
- ✓ Cleaning aluminium and other soft metals with either technique should be done with extreme care, especially while using a steel scraper or brush. Steel or plastic scrapers are used to remove old gasket material from a surface and heavy sludge. Power tools with a small sanding disc (normally emery cloth) are available. These are designed to remove all soft materials without damaging the hard metal surface.

Figure 123 abrasive cleaning

Thermal cleaning:

It is flame cleaning of structural steel with an oxyacetylene flame. This process relies on heat to bake off or oxidize dirt and other contaminants. Thermal cleaning ovens, especially the pyrolytic type, have become increasingly popular. A cleaning furnace is used.

Figure 124 thermal cleaning machine

The main advantage of thermal cleaning is a total reduction of all oils and grease on and in blocks, heads, and other parts. The high temperature inside the oven (generally 650°F to 800°F [343°C to 426°C]) oxidizes all the grease and oil, leaving behind a dry, powdery ash on the parts. The ash must then be removed by shot blasting or washing.

✓ Content/Topic 2 introduction to cleaning medium products

Different types of cleaning mediums

Different cleaning agents are used depending on the item to be cleaned, the cleaning method and the type of soiling found on the item. There are 3 main types of cleaning agents used in commercial garages:

- ✓ Soap
- ✓ Chemicals (Detergents, Degreasers, Abrasives)
- ✓ Acid

1. **Soap**

Soap is a salt of a fatty acid used in a variety of cleansing and lubricating products. In a domestic setting, soaps are surfactants usually used for washing, bathing, and other types of housekeeping. In industrial settings, soaps are used as thickeners, components of some lubricants, and precursors to catalysts.it can be liquid, powder or bar.

2. **Chemicals**

i) Detergents:

Detergents are the most common type of cleaning agent and are used in home and workshop. They work by breaking up dirt or soil, making it easy to wash it away.

The detergents are usually synthetic detergents made from petroleum products and may be in the form of powder, liquid, gel or crystals.

ii) Degreasers:

Degreasers are sometimes known as solvent cleaners and are used to remove grease from surfaces such as oven tops, counters and grill backsplashes.

iii) Abrasives:

Abrasives are substances or chemicals that depend on rubbing or scrubbing action to clean dirt from hard surfaces.

Abrasives should be used with care as they may scratch certain types of materials used for tools and equipment.

3. **Acids:**

Acid cleaners are the most powerful type of cleaning agent and should be used with care. If they are not diluted correctly and acid cleaners can be very poisonous and corrosive.

During the lubrication procedure, grease is forced between two surfaces that move or rub against each other. The grease reduces the friction produced by the movement of the parts.

Greases are made from oil blended with thickening agents. There are a few synthetic greases available that meet the same standards as petroleum greases.

Lubricants:

- ✓ A substance used for lubricating an engine or component, such as oil or grease. "squirt in a lubricant on a regular basis".
- ✓ A substance, as oil or grease, for lessening friction, especially in the working parts of a mechanism.

Greasing:

Advantage of greasing (oiling) As described below, periodical greasing (or oiling) will improve the performance of self-lubricating bearings:

- ✓ Reduction of co-efficient of friction and wear amount
- ✓ Increase of allowable PV value

- ✓ Improved reliability and safety
- ✓ Discharge of wear particles and improvement of foreign particle tolerance
- ✓ Rust-proof of the mating shaft
- ✓ Cooling effect Lubricating oil

✓ **Lubricating:** is a process or technique of using a lubricant to reduce friction and wear ,tear in contact between two surface

LO 3.3 – Test fuel supply system

✓ Content/Topic 1 Checking leakage of the fuel supply system

Troubleshooting fuel injection systems requires systematic step-by-step test procedures,

Check leakage of the fuel supply system;

a) Check pipes

- ✓ Any fuel leak, however small, can cause a fire. Do not drive a car with a suspected leak until you have cured it.
- ✓ Never leave a car dripping petrol where a passer-by may throw a cigarette end under it.
- ✓ A small fire extinguisher, fitted where you can get at it quickly, is a valuable accessory.
- ✓ Whenever you check fuel pipes, disconnect the battery to prevent stray sparks igniting petrol or petrol vapour.
- ✓ Above all, put out all naked lights and cigarettes.
- ✓ Use a torch rather than an inspection lamp, which could start a fire if the bulb is accidentally broken.

✓ Leaks can be caused by corrosion in steel pipes, and cracks and abrasion in all types.

✓ The clips holding the pipe to the chassis may damage it, or they may rust and fall off so that the pipe becomes loose. It .may then get dangerously close to the exhaust pipe.

✓ The pipe may also be damaged by stones on unmade roads, or even by jacking the car up with the jack in the wrong place.

✓ Apart from damage to the pipe itself, joints may come loose and leak.

Rubber joints may fray, or the clips loosen. Metal joints tend to leak when they have been pulled or pushed, so that the olive or expanded pipe end is distorted and no longer forms an effective seal with its connector.

Pipe Inspection

- ✓ All fuel lines should occasionally be inspected for holes, cracks, leaks, kinks, or dents. Since the fuel is under pressure, leaks in the line between the pump and injection assembly are relatively easy to recognize. Rubber fuel hose should be inspected for leaks, cracks, cuts, kinks, oil soaking, and soft spots or deterioration.
- ✓ If any of these conditions is found, the fuel hose should be replaced. When rubber fuel hose is installed, the hose should be installed to the proper depth on the metal fitting or line Steel tubing should be inspected for leaks, kinks, and deformation

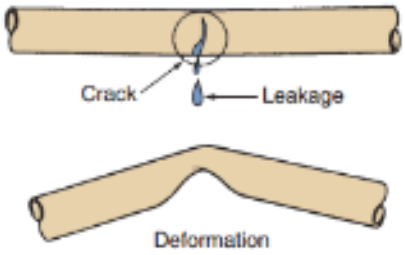


Figure 125 damaged pipe

- ✓ Steel tubing should be inspected for leaks, kinks, and deformation**;** Tubing should also be checked for loose connections and proper clamping to the chassis. If the tubing's threaded connections are loose, they must be tightened to the specified torque.
- ✓ Some threaded fuel line fittings contain an O ring.
- ✓ If the fitting is removed, the O-ring should be replaced.
- ✓ Nylon fuel pipes should be inspected for leaks, nicks, scratches and cuts, kinks, melting, and loose fittings. If these fuel pipes are damaged in any way, they must be replaced.
- ✓ Nylon fuel pipes must be secured to the chassis at regular intervals to prevent fuel pipe wear and vibration.

Check fuel pressure:

How to Use a Fuel Pressure Tester

- ✓ As you probably know, an engine only needs four things to run: air, fuel, spark, and compression.
- ✓ Checking an ignition tester can easily verify ignition operation, and a fuel pressure tester is nearly as easy to operate. The simple design consists of a gauge attached to a fuel hose and multiple fittings.
- ✓ The various fittings connect to the fuel system of nearly any vehicle.
- ✓ When it's connected and the fuel system is pressurized, the tester displays the pressure in psi on a large gauge visible from inside the vehicle.
- ✓ This allows you to verify fuel pressure while sitting in the driver's seat, making testing fuel pressure a one-person operation.
- ✓ If you don't know what your engine needs, grab a repair manual and check the specifications section.
- ✓ While zero fuel pressure means the engine won't run, low pressure sometimes allows engine operation with issues.
- ✓ A slow start-up, low performance, misfires, and stalling are common signs of low fuel pressure. High fuel pressure will cause excessive fuel consumption, black smoke from unburned gas, an overheating catalytic convertor, and rough idle.

Figure 126 fuel pressure tester

How to connect a fuel pressure tester

Note: Fuel vapors are even more flammable than liquid fuel, so be sure to perform these steps in a well ventilated area with a fire extinguisher nearby.

Step 1: With an entirely cold engine, pop the hood. Find a Schrader valve fitting on the fuel rail. Most vehicles will have them, although it may be hidden under a fuel rail cover or other plastic engine cover.

Step 2: Remove the Schrader valve cap. Attach the appropriate fuel pressure tester fitting. Make sure it threads on properly for a leakproof fit. Turn the ignition to "on," not start.

Step 3: Check the psi reading Wait and watch for a psi drop indicating a leak in the system. If it's still reading the same after 5 or 10 minutes, the system is holding pressure well.

Step 4: If the fuel pressure drops over 10 minutes let's say it loses 20 psi in that time that means there is a leak in the fuel system.

Step 5: Look for drips underneath to help narrow down the location. Realize it could be leaking internally from a bad fuel injector.

Step 6: Then start your engine, and let it idle You should see steady fuel pressure, within a few psi of recommended pressure.

Step 7: Once warmed up, give the engine a slow rev, making sure pressure rises with RPMs. If your fuel pressure holds steady, rises with engine speed, and is at recommended pressure, then your engine problem does not seem fuel related.

Understanding fuel pressure readings

So now that you have a measurement of fuel pressure and what a repair manual recommends for your vehicle, let's look at what could cause your fuel issue.

Zero fuel pressure : This means the pump is dead or not getting power. First, check the fuel pump fuse. Then verify power to the pump with a multimeter, and if it's good, swap out the fuel pump.

Low fuel pressure: The fuel filter could be clogged, or the pump could be failing. If it is a serviceable type filter, spend just a few bucks and change the fuel filter. This could also be improper tank venting, an emissions issue cause by a loose gas cap. Check that the cap gasket isn't damaged, and tighten it until it clicks.

High fuel pressure: This one has a couple of suspects, but start by looking for a clogged or kinked fuel return line. This could also be a bad fuel pump driver module or powertrain control module.

These would likely store a code and show a "check engine" light. High fuel pressure can also be caused by a faulty fuel pressure regulator.

✓ Content/Topic 2 Testing shut-off solenoid valve and fuel injector

a) Test shut- off solenoid valve

How to test a solenoid valve

1. Set your multimeter on ohms. If the multimeter is not automatic set it on 2k
2. Place the probes of multi meter acrosss the pin of solenoid coil. If you find 3 pins there, one of them is a flat pin which is connected to the ground
3. Read the number on the multi meter a functional solenoid coil normally has its resistance with certain range. But not definetly zero.cif you have 0 ohms it means the solenoid coil is shorted. While the infinity read indicate the coil is open or the wire is broken inside.

b) Test fuel injector

Voltage testing

1. Turn the ignition key to the on position. You do not need to start the engine for this test
2. Disconnect the electronics plug wire from the fuel injector
3. Turn multimeter to volt insert the black and red leads onto each side of the fuel injector electronic plug. Because you are testing the current it is not necessary to have a specific lead on a specific side of the plug
4. Read the multimeter the voltimeter should read approximately 12volts, replace the wiring for any single wire set whict faits the 12volt test. Besure to test all the wire before replacing any single set, mass faillure may indicate a faillure in electronic fuel injection relay or control module.

Fuel injector resistance testing

1. Turn the multimeter to ohm
2. Place the multimeter leads into the fuel injector plug terminal, it is not necessary to have black or red lead on a specific side of the plug termianl
3. Read ohm resistance produced by fuel injector note the value down
4. Test all fuel injectorohm reading , compare the value of each injector to the other ones value,operational of fuel njector will have the same, or very similar ohm values. Afailed injector will have too little or too much resistance and ohm value will be widely different than the other readings. Replace the injector if the ohm value is significantly different than other injector. Failed injector may still fire leading you to believe problem is wiring.

Electrical short testing

1. Disconnect all the fuel injector electronics plug on the engine
2. Set a multimeter to volts connect the multimeter red lead to one of the disconnected plugs, connect the black lead to the vehicle paterry positive terminal
3. Have an assistant start the engine, the engine rotation will charge the fuel injector electronic plug, as the engine turns , the voltage on the multimeter should alternate between 12 volts and 0 vlts, keep the multimeter attached to the plug.
4. Connect one of the other fuel injector plugs to the associated fuel injector, turn over the engine and recheck the voltage on the multi meter, continue attaching more more plug and retesting untill all plugs are attached or until the multimeter fails to display a 12 volt to 0volt alternation.

Note: replace the injector associated with the plug which when connected resulted in multimeter test faillure. Ashorted fuel injector will prevent electricity from activating the solenoid in the other plugs.

Part 1 Listening for Bad Fuel Injectors

Step 1 Put on the appropriate safety gear.

- ✓ Before beginning any automotive project, you need to take steps to protect yourself from injury.
- ✓ Eye protection like safety glasses or goggles will keep debris from falling or spraying into your eyes while you work.
- ✓ Choose eye protection that fits comfortably and won't interfere with your vision.
- ✓ Gloves are an optional addition to the safety gear required for this task.
- ✓ Gloves can protect your hands from sharp objects or pinches while working in the engine bay.
- ✓ Eye protection is required for this project.

Step 2: Open the hood and locate your fuel injectors.

- ✓ The easiest way to locate the fuel injectors for your specific vehicle is to refer to the service manual for that vehicle. Most applications have one fuel injector for each cylinder.
- ✓ They are usually located on the intake manifold and are connected to one another with a fuel rail.
- ✓ The fuel rail is a cylindrical rail that will run along the top of the intake manifold, and each fuel injector will be between the fuel rail and the intake manifold.

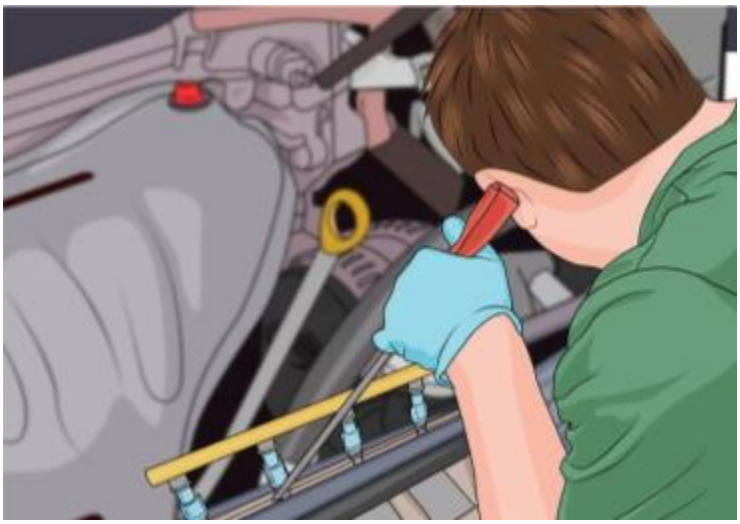
- ✓ V style engines (V6, V8, V10) will have two fuel rails with half of the injectors on each side of the motor.

Step 3 Find a long metal rod or screwdriver. Locate a thin piece of metal that's at least a foot or so long.

- ✓ It should be made mostly of metal, but you could opt to use a screwdriver despite it having a plastic or rubber handle.
- ✓ Make sure the piece you choose is at least a foot long, but not more than two feet.
- ✓ A long screwdriver or thin piece of rebar will work fine.

Step 4: Place the tip of the rod on a fuel injector.

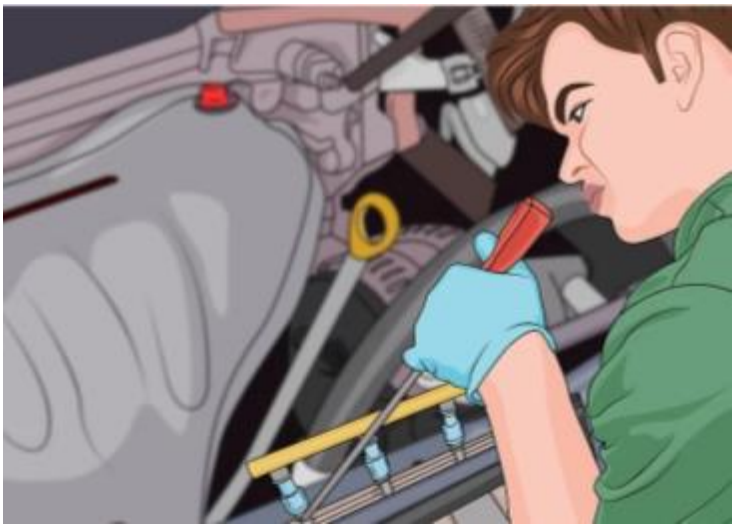
- ✓ You will be using the metal rod to transmit sound from the fuel injector to your ear without having to bring your face too close to a running engine.
- ✓ Set one end of the rod or screwdriver on the injector itself while holding it up with one hand.
- ✓ Make sure to hold the screwdriver or metal rod at an angle that will allow you to bring your ear to it.



Step 5: Bring your ear close to the rod and listen for clicking.

- ✓ Lean your ear close to the end of the metal rod or screwdriver that is opposite the injector.
- ✓ As the engine runs, listen for an audible clicking sound given off by the injector.

- ✓ This sound indicates the injector being activated.
- ✓ Be extremely careful leaning your head into the engine bay, and ensure you keep your eyes open as you listen to the rod to prevent accidentally getting injured.
- ✓ If you have long hair, tie it back tightly to prevent it from getting caught in any moving parts under the hood.



Step 6: Repeat these steps for each injector.

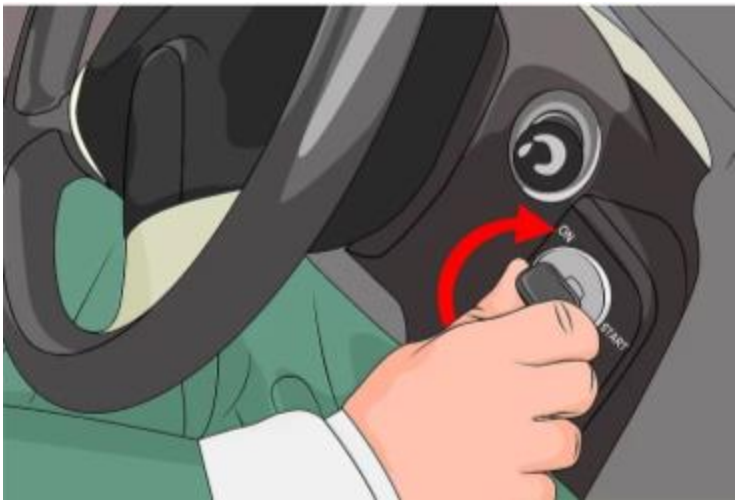
- ✓ Use the same method to check each fuel injector in your vehicle. If you find one that is not clicking, there is an issue with the injector or the electronic control that is transmitting to the injector.
- ✓ If you have an OBDII scanner and your vehicle's check engine light is on, you can check to see if there have been any errors in the vehicle's computer regarding that cylinder or injector.
- ✓ Replacing this injector may solve the problem, but you may also need to have a diagnostic done of your vehicle's electronic control unit and fuel system by a professional mechanic.

Part 2: Ensuring the Injectors Are Receiving Power

Step 1: Turn the key to the "on" position without starting the engine.

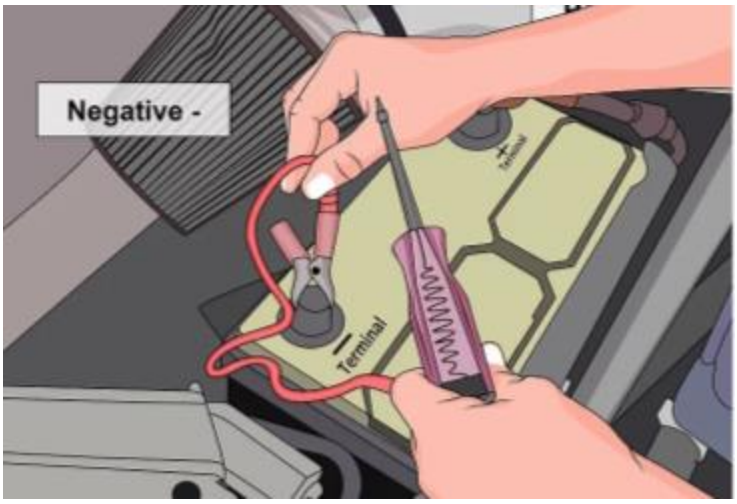
- ✓ To conduct this test, the vehicle's electrical system must be active without the engine actually running.

- ✓ Insert the key and turn it until the electrical system activates, but stop before you engage the engine's starter.
- ✓ This should activate all of the vehicle's electronics like interior lighting and the radio.
- ✓ If you accidentally start the vehicle, simply turn it off and try again.
- ✓ The vehicle's battery is powering everything during this test, so you should turn off things like the headlights and stereo to conserve power and ensure it has enough to start the vehicle again later.



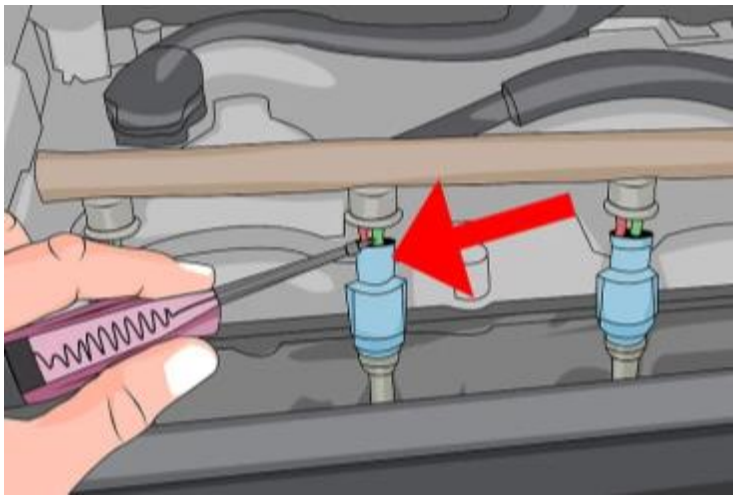
Step 2: Connect a test light to the negative terminal on the battery.

- A test light looks like a screwdriver with a finely pointed end and a wire hanging out of the handle.
- When the wire from the handle and the pointed end come into contact with a completed and powered circuit, a lightbulb lights up inside the handle of the test light.
- The wire extending from the handle will have an alligator clip at the end.
- Attach that alligator clip to the negative terminal of the vehicle's battery.
- You can identify the negative terminal on the battery by looking for the negative symbol (-) or the letters NEG.
- Make sure the clip has a good metal on metal connection to make the test light work.



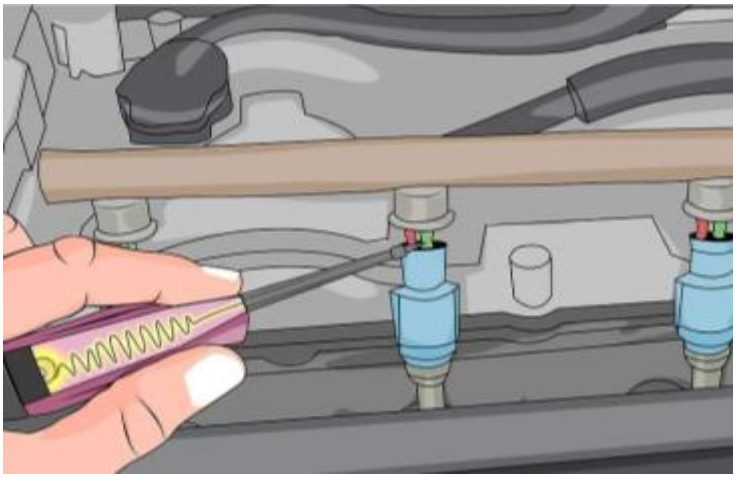
Step 3: Locate the two wires going into each injector.

- ✓ Each fuel injector will have a metal clip plugged into it with two wires coming out of it.
- ✓ One of those two wires is a 12-volt constant that should be continuously receiving power from your vehicle's electrical system.
- ✓ There should be a small portion of each wire exposed coming out of the plastic clip that connects to the injector.
- ✓ These wires are often grey and black, but can come in any number of colors.
- ✓ They will be the only wires coming from each injector.



Step 4: Test each wire for voltage.

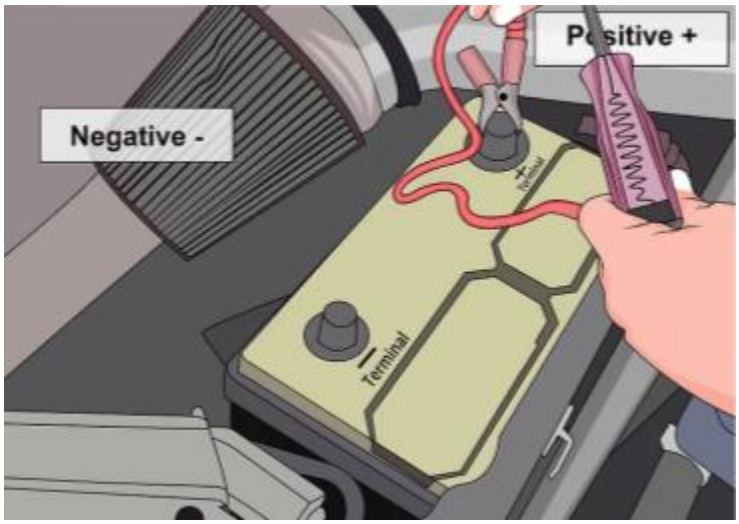
- ✓ Take the sharp end of the test light and press it firmly into the rubber coating around each wire until it penetrates into the metal wiring itself.
- ✓ One of the two wires should make the test light turn on when it comes into contact with the wire inside the protective coating.
- ✓ If the test light turns on with one wire, then the injector is receiving the necessary constant voltage.
- ✓ Make sure to wrap a piece of electric tape around any holes in the wiring's protective coating that are big enough to see.
- ✓ If neither wire makes the light turn on, then there is an issue with the power reaching the fuel injector, which will result in in failing to fire.
- ✓ If the all of the wires that light up are a certain color, make note of which wires are the constants.



Step 5: Repeat the process for each injector.

- ✓ Test each wire coming out of the fuel injectors in your vehicle.
- ✓ If you locate one injector with a power issue, that doesn't mean others may not have the same problem.
- ✓ Once you identify an injector with a power issue, make a note of which one it was and continue to test the rest.
- ✓ Follow the wires on the injectors that fail to engage the test light to make sure there are no breaks in the wire that may prevent the electricity from reaching it.

Part 3 Checking the Trigger Circuit for the Injectors

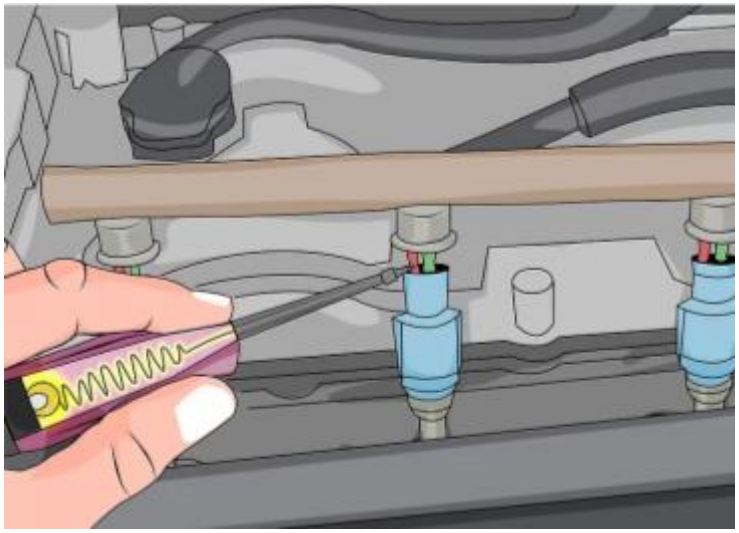


Step 1: Connect a test light to the positive terminal of the battery.

- ✓ Take the same test light that you used for the previous test, but this time connect the alligator clip to the positive terminal on the battery instead of the negative.
- ✓ You can identify the positive terminal by looking for the positive sign (+) on the battery or the letters POS.
- ✓ Make sure the alligator clip has secure, metal on metal contact or the test light will fail to function.

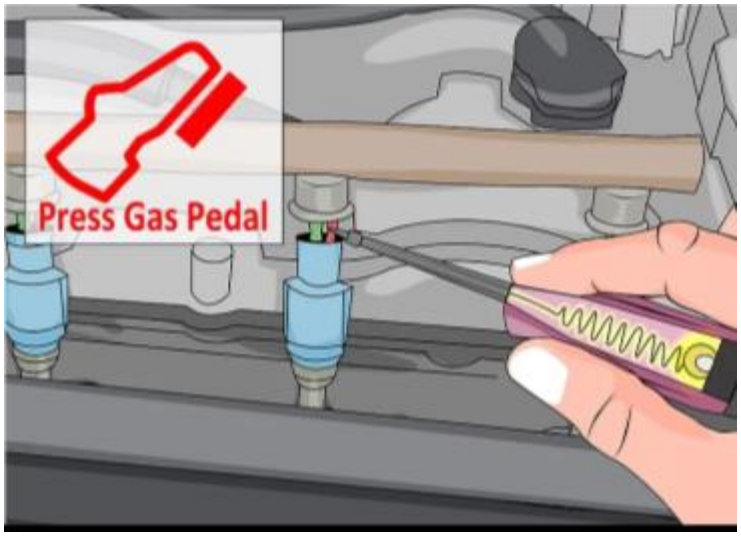
Step 2: Have a friend start or turnover the engine.

- ✓ Have a friend start the engine. If the vehicle won't currently run, have your friend attempt to turn it over as you test each injector.
- ✓ Make sure you do not have any clothing or body parts hanging into the engine bay as it starts or turns over.
- ✓ If the engine won't start, remember that attempting to turn it over for too long can kill the battery and damage the starter.
- ✓ Only attempt to turn it over with the test light in place.



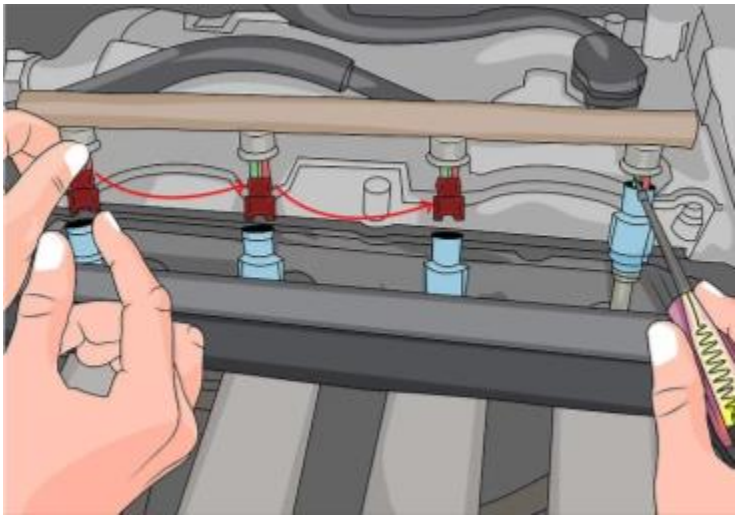
Step 3: Probe the opposite wire with the test light.

- ✓ Use the test light and check the opposite wire of the constants you identified in the previous test. Press the sharp end of the probe through the rubber coating firmly until it makes contact with the metal wire inside.
- ✓ Be careful not to press the probe all the way through the wire and out the other side.
- ✓ Always cover holes in the wire's protective coating with electric tape once you're done.



Step 4: Look for flashing or flickering light.

- ✓ With the engine running at an idle, the test light should flicker dimly and as your helper applies throttle by pressing the gas pedal, the light should flicker more brightly. This light represents the signal being transmitted by the ECU to the injector to spray fuel.
- ✓ If the test light is failing to light up, the injector may be bad or there could be an issue with the electronic control unit for the vehicle.
- ✓ This issue could be caused by a failing ECU, or one of the injectors along the fuel rail may be faulty.
- ✓ The electrical pulse is transmitted through each of the injectors to one another, so one faulty injector could cause issues in multiple injectors.



Step 5: Disconnect the wiring clips to each injector and begin the test again.

- ✓ With none of the injectors connected, the flickering pulse should transmit through all of the wires without any issue.
- ✓ Use the test light to confirm this on the wire for the last fuel injector clip (at the end of the fuel rail). Keep the test light connected as you reconnect each fuel injector one by one.
- ✓ As you connect each injector, the pulse intensity should remain the same. It shouldn't change until you connect a faulty injector that creates too much resistance for the pulse to travel through easily.

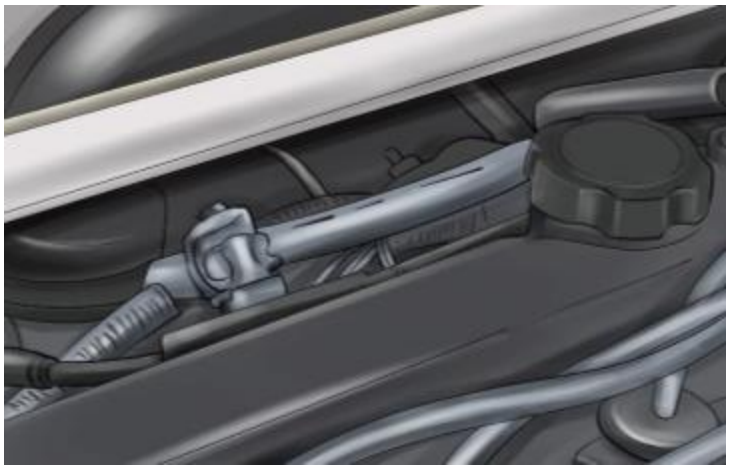
- ✓ When the pulsing light dims as you connect one of the injectors, that injector is faulty and needs to be replaced.

- **Content /Topic3 Testing Injection Pump and Injectors**

Test electrical driven delivery pump:

Step 1: Listen for the fuel pump to run.

- ✓ Turn the key to "on" without starting the care and listen for a "whirring" noise to occur.
- ✓ It should last for about two seconds and should be coming from the rear of the vehicle as the pump is in the gas tank.



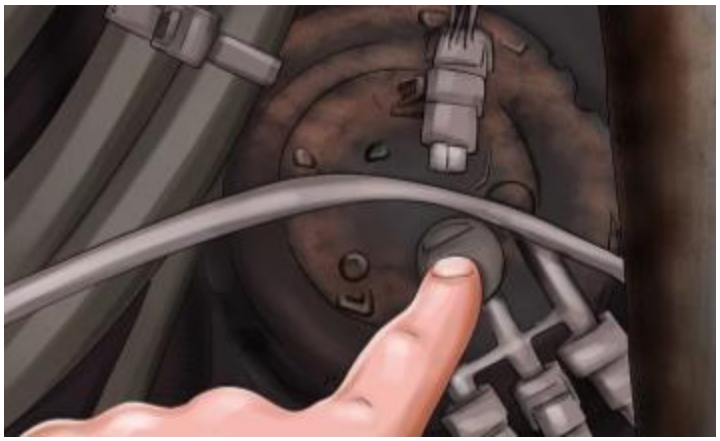
Step 2: Listen for the relay to switch.

- ✓ The relay is in the inner passenger side fuse box. Turn the key to "on" without starting the care and listen for a click coming from the relay.

Step 3: If the relay is not "clicking," try swapping it for the relay that controls the horn (if the horn is working).

Step 4 Test for voltage to the pump.

- ✓ Peel back the carpeting in the trunk on the driver side paneling behind the wheel well.
- ✓ There is a connector there with three wires: green, black, and grey.
- ✓ Use a multi-meter to probe the hot grey wire and touch a ground.
- ✓ Turn the car to "on" and you should see 12V for 2 seconds.



Step 5 Test the ground on the pump.

- ✓ Test for continuity between the ground contact on the fuel module and another ground (bare metal) on the car.

Step 6 If you have voltage to the pump and the ground is good, then you may have a faulty fuel pump. You may also have a dirty and blocked fuel filter.

- **Content /Topic3 Testing Injection Pump and Injectors**

Testing Injection Pump and Injectors

- ✓ Check diesel fuel level on the tank of injector pump tester
- ✓ Fix injection pump on injection pump tester
- ✓ Screw the supply and return pipe on injection pump
- ✓ Test the starting, idle and full load speed statements

After testing pump Fuel Bleeding is necessary

Procedures

a) If you tried to start your tractor BEFORE bleeding the system or you ran out of fuel you will need to follow all of the steps below (because you have now introduced air through the pump into the rest of the system).

b) If you are changing your filter, valve, etc and and have NOT tried to start the tractor yet- you can stop after doing step #3 (because the air has not made it through the pump yet and it is easier to bleed)

1- Fill the tank completely full of fuel. This will help add pressure to the fuel system and flush out the air much faster. Don't skip this step- it makes things much easier!

2- Locate the bleeder screws at the top of the fuel filter valve (the part that the fuel bowl is attached to). Open the left screw at the top (10mm wrench) a few turns and wait for fuel to run out.

- ✓ Once there are no more bubbles coming out tighten screw back up and repeat with the screw on the right. This will indicate that the filter is full of fuel.
- ✓ If you did not fill the tank there will typically not be enough pressure to force the fuel through the filter.
- ✓ Do not over-tighten your bleeder screw, This is a very small screw that has a hole through it.
- ✓ It does not take much to twist it off.

Note: Some newer models have a fancy (leak-prone) spring-loaded pushbutton bleeder. The same procedure applies, just push the button instead of loosen a screw).

3- Follow the fuel hose up to the injection pump.

- ✓ There will be a small bleeder screw (10mm wrench) on the pump where the fuel line goes in to the pump.
- ✓ Loosen it and wait for all of the air bubbles to come out then tighten.
- ✓ You should be getting straight fuel to your injectors now.

5- While sitting on the seat, crank engine at full throttle until you see no more air bubbles coming out of the lines.

- ✓ Do not crank for longer than 10 seconds at a time, letting starter cool 1 minute between attempts.

7- The tractor should start now. Let idle for a few minutes to get out the remainder of the air.

Note: Never operate starter for longer than 10 seconds at a time. Allow several minutes for starter to cool before re-trying.

- ✓ Check engine oil pressure light and temperature light.
- ✓ They should both be off. If the red light is on after 10-15 seconds of running, or the amber light comes on- shut off imediately.
- ✓ You could be causing permanent damage. Locate the problem before running again.

Learning Unit 4 – Repair fuel supply system

LO 4.1 – Select tools, materials and equipment

✓ Content/Topic1 Selection of required hand tools

Hand tools selection

Tools selection	Materials selection	Equipment selection
✓ Wrenches ✓ Open-End Wrench Box-End Wrench ✓ Allen Wrench ✓ Sockets and Ratchets ✓ Torque Wrenches ✓ Extensions ✓ Screwdrivers ✓ Pliers ✓ Hammers	✓ Sand paper ✓ Anti-rust ✓ soaps	✓ Multimeters Hand scanner ✓ Various scan tool connectors for OBD-II systems. ✓ Injector tester ✓ Injection pump tester

LO 4.2 – Repair distributor pump

✓ **Content/Topic 1 Process of repairing distributor pump**

Step 1 Remove the pump from engine

- ✓ Remove the injection pipe clip from the injection pipe.
- ✓ Remove the injection pipe from the injection pump and the injection nozzle.
- ✓ Note: Loosen the sleeve nut and remove it. Do not apply excessive force to the injection pipe. Plug the delivery holder ports with the caps to prevent the entry of foreign material.
- ✓ Remove the high pressure injector lines
- ✓ Before this step, ensure your ignition is off. You will be working in close proximity to the starter solenoid which can provide a strong shock if you short it by mistake. Maybe even test it with a multi-meter first just in case.
- ✓ Also be careful not to drop any foreign matter into the fuel ports. Tiny specks matter. Block off the ports as you go with tape or something.
- ✓ Undo all four fuel line connections at the fuel injector side.
- ✓ Then undo the other end of the four lines where they attach to the fuel injector pump.
- ✓ To get to the hard-to-reach ends, it may help to remove the raw water cooling hose. You'll know the one. It's preventing you from getting both hands to the injector pump. Once it's free you can move it the few inches to get your hands in there.
- ✓ Slacken all the fuel line fittings on the pump, then snake the four high pressure fuel lines out.

Step 2 Fix injection pump on injection pump tester

Step 3 Test injection pump and injectors on injector nozzle tester

- ✓ Proper fixing of injection pump on its mounting on injector pump tester
- ✓ Starting injector pump tester
- ✓ Set the direction rotation of injection pump on the injector pump tester
- ✓ Setting of starting, idle and full load RPM of injection pump and check the fuel quantity in the test tubes
- ✓ Comparison of the given data with the manufacture's indicationPage 25of 26
- ✓ Adjusting the fuel flow on the injection pump referring to the manufacturers indication
- ✓ Remove the injection pump to the pump injector tester bench.

Step 4 Assemble Pump assembly with distributor head

1. Rotor
2. Roller ring
3. Cam plate
4. Distributor plunger foot
5. Distributor plunger
6. Link element
7. Control collar
8. Distributor head
9. Delivery valve holder
10. Plunger Return spring

Step 5 Retest on injection pump test

Step 6 Reback on the engine

LO 4.3 – Repair in line pump

- ✓ **Content/Topic 1 Repairing inline injection pump**

Step 1 Remove the pump from engine

1.Injection punp bracket removal

- ✓ Remove the injection pump bracket from the injection pump.

2.Injection pump removal

- ✓ Disconnect the engine harness from the injection pump.
- ✓ Remove the injection pump from the timing gear case.

Note: Before removing, place alignment marks on idle gear B and the injection pump gear.

Step 2 Fix it on injection pump tester

Step 3 Perform testing

- ✓ Check diesel fuel level on the tank of injector pump tester

- ✓ Fix injection pump on injection pump tester
- ✓ Screw the supply and return pipe on injection pump
- ✓ Test the starting, idle and full load speed statements

Step 4 Steps to Assemble Fuel Injection Pump

(1) Install fuel injection pump flange, apply a small amount of lubricating oil on pump rubber ring;

(2) Screw on the hexagon bolts to connect fuel injection pump and the flange;

(3) Install injection pump gears, specification of fuel injection pump gear lock nut is M24× 1.5,tighten the nut to 250~300Nm directly;

(4) Install the threes pump fixing studs on engine block;

(5) Rotate the flywheel until cylinder 1 reaches compression TDC, at this point rotate injection pump gears until the mark on injection pump gear module is aligned to mark on injection pump flange, install injection pump module. Insert a Φ4 pin into the corresponding hole on middle flange and pump gear, pull out the pin after fastening common rail module, and seal the hole up with M5 screw (applied with sealant).

After the assembly, the mark on driving gear of injection pump should be aligned to mark on driven gear

Disassembly, Inspection, Maintenance and Assembly of High Pressure Fuel Pipes

Step 4 b) Steps to Disassemble High Pressure Fuel Pipes

(1) Remove high pressure fuel pipe support;

(2) Remove the high pressure pipe between pump and common rail;

(3) Remove the high pressure pipe between common rail and injector;

Note: Steps to Assemble High Pressure Fuel Pipes Assembling steps are contrary to disassembling ones.

Attention: Tightening torque of high pressure fuel pipe fastening nuts is 30~40Nm

Step 4c) Steps to Disassemble Fuel Injector

(1) Remove the hexagon bolts that used to fix injector pressing block;

(2) Remove injector pressing block and fixed block;

(3) Take injector assembly out of cylinder cover.

Note: Inspection and Maintenance of Fuel Injector Replacement of injector should be performed at authorized maintenance service station.

Step 4 d) Steps to Assemble Fuel Injector

(1) O-shape seal rings of injector and high pressure joints, high pressure joint thread, and fittingsurfaces of high pressure joint and nuts must be applied with lubricating oil

(2) All kinds of protective caps only need to be removed before assembling;

(3) Place the injector into cylinder cover and tighten injector clamping bolt to 3Nm;

(4) Loose injector clamping bolt until axial force posed on injector is 0kN;

(5) Pre-tighten high pressure joint to 15~20Nm (nuts);

(6) Tighten injector clamping bolt for 10Nm+120° ;

(7) Tighten high pressure joint to 50~55Nm (nuts);

(8) High pressure joint, O-shape seal rings and sealing gaskets are disposal and cannot be reused,check the O-shape seal rings and sealing gaskets for sealing performance after assembling

Step 5 Retest on injection pump tester

Step 6 Reback injection pump on the engine

LO 4.4 – Test fuel system

- ✓ **Content /Topic1 Testing of fuel leakage**

Check for leaks:

- ✓ Place a paper towel under the fuel injectors and turn the ignition to the on position but do not start the engine. If you find fuel on the paper towels, then the injector is leaking.
- ✓ Diesel fuel is closer to oil than it is to gasoline. It too has a distinctive odor, and also feels slick between your fingers like oil does. Diesel is not as volatile as gasoline, but you still need to address a diesel fuel leak sooner rather than later.
- ✓ Diesel fuel works best under pressure. Diesel engines use this high pressure in their fuel systems to atomize the fuel when it's injected into the combustion chamber.
- ✓ This is the heart of the system, really. If there's a loss of pressure or there's air in the fuel system, the engine won't run.
- ✓ So if you have a diesel fuel leak and your engine won't start, repair the fuel leak, bleed the air from the system, and try again.

Symptoms of a Fuel Line Leak

- ✓ Car seems to be using more fuel than usual
- ✓ You smell a strong gas odor

Note: This means when there is a leak present that the "fuel will spray out of the line causing a mist or a vapor which is extremely dangerous, especially if near the exhaust or engine."

How to Spot a Fuel Line Leak

- ✓ Place Your Vehicle on Jacks the fuel line runs from the rear of the car to the front, You can follow along the line with a flashlight.
- ✓ If you spot areas that have a buildup of dust and road grime, as well as areas with wet spots, then you have found evidence of a fuel leak,
- ✓ Add a Dye to your Fuel there are dyes that you can add to your fuel that will glow under a black light. This method helps highlight the location of a fuel leak.
- ✓ Use a Fuel Detector This device will detect the compounds that are found in gasoline and diesel, so if you can smell the presence of gasoline, but are unable to locate it with a flashlight or dye, the fuel detector is a third option.

Note: Leaving a leaking fuel line alone is not only hazardous to your health, but the gasoline can also "degrade the rubber in your tires

✓ **Content /Topic2 Testing of fuel pressure**

Testing of pressure

a) **Check Fuel Pressure With a Gauge**
   - ✓ Using a fuel pressure tester gauge is a precise and easy way to get real results.
   - ✓ Every car has a fuel pressure testing point, usually located near the car hood's fuel injectors.
   - ✓ Start by disconnecting the hose or pipe that came to the injector's rail.
   - ✓ Connect the pressure gauge in this pipe with the specific port to ensure there is no pressure leakage.

   - ✓ Have a helper to start up and rev up the car as you check the gauge values.
   - ✓ Check the values specs from the shop manual of the car.

- ✓ Check what is the pressure when on idle speed or at load and compare it with prescribed values. If you have a problem accessing a sophisticated fuel pressure gauge, you can check fuel pressure with a tire gauge.

The Fuel Pressure

- ✓ Every engine is designed to have different fuel pressure.
- ✓ This is specified from the engine displacement, horsepower, and torque to be delivered.
- ✓ All these parameters require a certain pressure at different situations of operation.
- ✓ For instance, the Toyota rav4 fuel pressure test shows that the pressure should range from 44-50 psi. In general, most vehicles' fuel pressure range is between 40 – 80 psi.

The Symptoms of a Bad Fuel Pressure Regulator

- ✓ If the regulator goes bad for some reason, there are some common signs that indicate it needs replacement.
- ✓ One of these signs is your car produces black smoke.
- ✓ This means that the car is burning too much fuel than it should.
- ✓ This is the first sign of a bad fuel regulator.

Fuel Pressure Be At Idle

- ✓ Fuel pressure always varies depending on the load of the engine.
- ✓ The more the engine load is the higher the fuel consumption, thus reducing fuel pressure when on the idle state.
- ✓ Fuel pressure varies from car to another, but it always around 40 psi.

Steps on How to check Fuel Pressure without a Gauge

Step 1: The most basic and easiest test is hearing the fuel pump buzz when you try to start your car.

- ✓ If you turn the key from OFF position to ON and fail to hear the pump buzz, this may be a sign that you need to do a replacement.

Step 2: Disconnect the hose coming from the pump to the filter and block the passage of the hose tightly with your finger. You can then start the car.

- ✓ If you feel that the fuel is pushing your finger hard, it means you have good pressure. If not, then you require replacing the pump.

Step 3: The problem may not be in the fuel pump itself; You may be required to replace the fuel filter. When the fuel filter is full of particles and impurities, it blocks the fuel passage, leading to low-pressure problems.

Step 4: Try to check the fuel pipelines that came out from the fuel pump and take fuel to the engine.

- ✓ These pipes are made from fuel line materials Opens in a new tab., specially designed for this purpose. These pipes pass underneath the car.
- ✓ When the car is exposed to a harsh environment such as street bumps or potholes, these pipes are affected.
- ✓ To return it back to its normal state, you will require tools such as fuel line flaring tool and Fuel Line benders.

✓ **Content /Topic3 Testing of voltages**

Testing of voltages

The pump voltage test is important for checking the effectiveness of the fuel pump. Here's how to perform the test.

Step 1 - Prepare the Settings

- ✓ Connect the digital multimeter to the positive and negative terminals of the fuel pump. Make sure there are no broken circuits anywhere between the fuel pump and relay.

Step 2 - Switch Ignition

- ✓ Insert the key into the ignition and turn on the key without starting the engine.
- ✓ A soft whirl sound should come from the pump indicating that it is ready to pump fuel into the engine.
- ✓ If the pump is functioning, find out if it is receiving enough electrical power.
- ✓ A deficiency in power supply may cause the digital multimeter to indicate a false voltage reading at the pump.
- ✓ To confirm the reading it is necessary to perform a voltage drop test.

Step 3 - Test Negative Terminals

- ✓ Split the circuit into two.
- ✓ Have the ground phase on one side and the positive on the other.
- ✓ Use the jumper wire to power the fuel circuit and energize the pump.
- ✓ Connect the digital multimeter to the battery and the pump, both on their negative terminals.
- ✓ Conduct the tests using a live circuit wire. If the meter indicates a reading of more than 0.1 then this indicates a loss of voltage power.
- ✓ The reason for the loss could be damaged harness connectors or poor wiring.

Step 4 - Test Positive Terminals

- ✓ Connect the digital multimeter to the positive terminals of the pump and the battery.
- ✓ Also test the output terminal of the fuel pump to see if it is functioning as expected.
- ✓ If the voltage drop is greater than the recommended reading of 0.1 volts then this is a confirmation that indeed the harness connectors or the wiring is faulty.
- ✓ You need to locate the exact location of the fault to correct the problem.

Step 5 - Testing Pump Relay

- ✓ Establish the location of the fuel pump relay on the dashboard or the engine compartment. Remove the relay and have someone switch on the ignition without starting the engine.
- ✓ Check for voltage at the relay connector using a digital multimeter.
- ✓ Replace relay and Test the fuel pump connector at the back of the car and test for incoming voltage using a digital multimeter.

Voltage drop test procedures

1. Address the negative side of the circuit first, then the positive side.

2. Connect one digital voltmeter test lead to the negative battery terminal and the other to the negative terminal at the fuel pump.

- ✓ On vehicles with a vacuum fuel pressure regulator, the diagnostic procedures may include actuating the diaphragm with a vacuum pump.

3. The fuel pump circuit must be energized to properly test it.

- ✓ Energize the fuel pump relay and power the fuel pump circuit. The majority of fuel pumps run for only a few seconds once the relay is energized (only long enough to prime the system) and until an RPM signal is generated.

4. If the negative circuit is in good condition, the voltage drop measured should be 0.5V DC or less. Larger voltage drop readings indicate a problem.

- ✓ Damaged or corroded vehicle wiring or harness connectors are likely sources of the problem.

5. Repeat the voltage drop test on the positive side of the circuit.

- ✓ Connect one digital voltmeter probe to the positive terminal on the battery and the other to the positive fuel pump terminal.

6. Energize the fuel pump relay and power the fuel pump circuit.

- ✓ The majority of fuel pumps run for only a few seconds once the relay is energized (only long enough to prime the system) and until an RPM signal is generated.

7. As with the ground circuit, voltage drop readings larger than 0.5V DC indicate system wiring or connector issues.

If a pump is out of specification and the dram is too high, it can indicate:

- ✓ problems with the fuel filter;
- ✓ fuel line restrictions; and/or
- ✓ Possibly a defective fuel pump.

If pressure is low and amperage is below specification, check:

- ✓ high circuit resistance, voltage side;
- ✓ high circuit resistance, ground side; and
- ✓ For a defective fuel pump.

Note: If pressure is high and amperage is above specification, it might indicate a restricted regulator and/or fuel return line.

✓ Content /Topic4 Testing of nozzle pressure

Testing of nozzle pressure

The tools you'll need to test your fuel injectors are relatively simple, and you probably have most of them lying around in your house or garage.

The list of items you'll need to test fuel injectors includes:

- ✓ Work gloves for safety
- ✓ Protective eyewear

- ✓ Long screwdriver or metal rod (about one foot in length)
- ✓ Automotive test light
- ✓ Use Your Senses

Accident prevention

- ✓ The high pressures involved mean that it is dangerous to touch the fuel spray because it can penetrate deep into the skin tissue. There is a danger of blood poisoning.
- ✓ Always wear protective goggles for all checks and tests. An extraction facility must be used because fuel vapors are hazardous to health.

Injection-nozzle test rig

This is used to check removed nozzle-holder assemblies for leaks, opening pressure and spray shape.

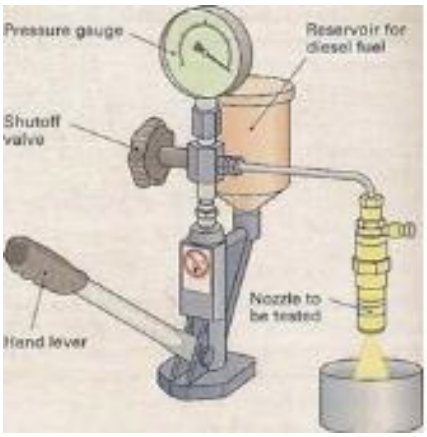


Figure 129 inector test rig

Test requirements:

For an exact nozzle check, clean the nozzle first and then carry out a slide test.

Slide test

The nozzle needle must slide naturally under its own weight into the nozzle body. Only the pressure pin of the nozzle needle may be touched during this test. Risk of corrosion!

Leak test

A nozzle is tight when no fuel droplets drip out within 10 seconds at a pressure of 20 bar below the nozzle-opening pressure.

Setting the nozzle-opening pressure

The closing force of the compression spring determines the opening pressure of the nozzle. Set the correct opening pressure for the nozzle-holder assembly by inserting adjusting shims under the compression spring.

Chatter test

- ✓ When setting the respective nozzle-opening pressure (varies from manufacturer to manufacture), check the spray pattern at the same time and listen out for a chattering noise when the nozzle needle is opened.

- ✓ While the injection nozzle is being opened, the pressure drops in such a way that the nozzle needle is pressed back onto its seat. Because fuel continues to be delivered, the pressure continues to rise and the nozzle needle lifts off its seat again.
- ✓ This opening and closing gives rise to a typical chattering noise. If this chattering cannot be clearly heard, then the nozzle guide is worn.

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