Vehicle engine overhauling

Level-III

Based on NOV 2016, Version 2 Occupational standard

Module Title: - Overhauling Diesel and Gasoline Fuel Injection System and Its Components

LG Code: EIS VEO3 M07 1220 (1-4) LG (27-30)

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LG #27	LO #1- Prepare for work

Instruction sheet

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

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

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

- Identify and confirm nature and scope of the work requirements
- Acquire procedures and information
- Analyse method options
- Source and support technical and calibration requirements for the testing and overhaul of diesel and gasoline fuel injection system
- Observe *OHS*, personal protection
- Source and observe applicable national environmental protection measure/ guidelines for diesel and gasoline vehicles

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.

5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets
7. Perform “the Learning activity performance test” which is placed following “Operation sheets”
8. If your performance is satisfactory proceed to the next learning guide,
9. If your performance is unsatisfactory, see your trainer for further instructions or go back to “Operation sheets”.

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

1.1. Fuel & Fuel System

1.1.1. Properties of Fuel

Fuel is a substance consumed by the engine to produce energy. The common fuels for internal combustion engines are:

1. Petrol
2. Power kerosene
3. High speed diesel oil
4. Light diesel oil.

The important properties of these fuels are given below:

S.No	Name of fuel oil	A. P. I. degree	Specific Gravity	Calorific value	
				kcal/kg	B.T.U./lb
(i)	Light diesel oil (L.D.O.)	22	0.920	10300	18600
(ii)	High speed diesel oil (HSD)	31	0.820	10550	19000
(iii)	Power kerosene	40	0.827	10850	19500
(iv)	Petrol	63	0.730	11100	20000

1.1.2. QUALITY OF FUEL

The quality of the fuel mainly depends upon the following properties:

- Volatility of the fuel
- Calorific value of the fuel
- Ignition quality of the fuel

Volatility: Volatility of fuel has considerable effect on the performance of the engine by affecting the following:

- Ease of starting the engine.
- Degree of crankcase oil dilution,
- Formation of vapor lock in the fuel system,
- Accelerating characteristics of the engine,
- Distribution of fuel in multi-cylinder engine.

In I. C. engine, all the liquid fuel must be converted into vapor fuel before burning. High speed diesel oil is most difficult to vaporize. Vaporizing temperature of high speed diesel oil is higher than that of the petrol, hence the petrol vaporizes quicker than diesel oil in

the engine cylinder. This helps in easy starting of petrol engines. Calorific value: The heat liberated by combustion of a fuel is known as calorific value or heat value of the fuel. It is expressed in kcal /kg of the fuel. The heat value of a fuel is an important measure of its worth, since this is the heat which enables the engine to do the work. Ignition quality: Ignition quality refers to ease of burning the oil in the combustion chamber. Octane number and cetane number are the measures of ignition quality of the fuel.

(a) Octane number*:* It is a measure of knock characteristics of a fuel. The percentage of is octane (C8 H18) in the reference fuel consisting of a mixture of is ooctane and normal heptane (C7H16), when it produces the same knocking effect as the fuel under test, is called octane number of the fuel. Iso-octane has excellent antiknock qualities and is given a rating of 100. Normal heptane would knock excessively and hence it is assigned a value of zero.

(b) Cetane number*:* The percentage of cetane in a mixture of cetane (C16 H34) and alpha methyl naphthalene (C11 H16) that produces the same knocking effect as the fuel under test is called cetane number of the fuel. Diesel fuels are rated according to cetane number which is the indication of ignition quality of the fuel. The higher the cetane number the better the ignition quality of the diesel fuel. The commercial diesel fuels have got cetane rating varying from 30 to 60.

Detonation (Knocking): Detonation or engine knocking refers to violent noises, heard in an engine, giving a pinging sound during the process of combustion. It occurs during the process of combustion of the mixture within the cylinder after the ignition has taken place. It is an undesirable combustion and results in sudden rise in pressure, a loss of power and overheating of the engine. It is caused by improper combustion chamber, high compression pressure, early ignition timing, improper fuel and inadequate cooling arrangement.

Pre-ignition: Burning of air-fuel mixture in the combustion chamber before the piston has reached the top dead center is called pre-ignition. Pre-ignition occurs when the charge is fired too far ahead of the top dead center of the piston due to excessive spark advance or excessive heat in the cylinder.

1.1.4. FUEL SUPPLY SYSTEM IN SPARK IGNITION ENGINE

The fuel supply system of spark ignition engine consists of:

(i) Fuel tank

(ii) Fuel filter

(iii) Sediment bowl

(iv) Fuel lift pump

(v) Carburetor

(vi) Fuel pipes

(vii) Inlet manifold

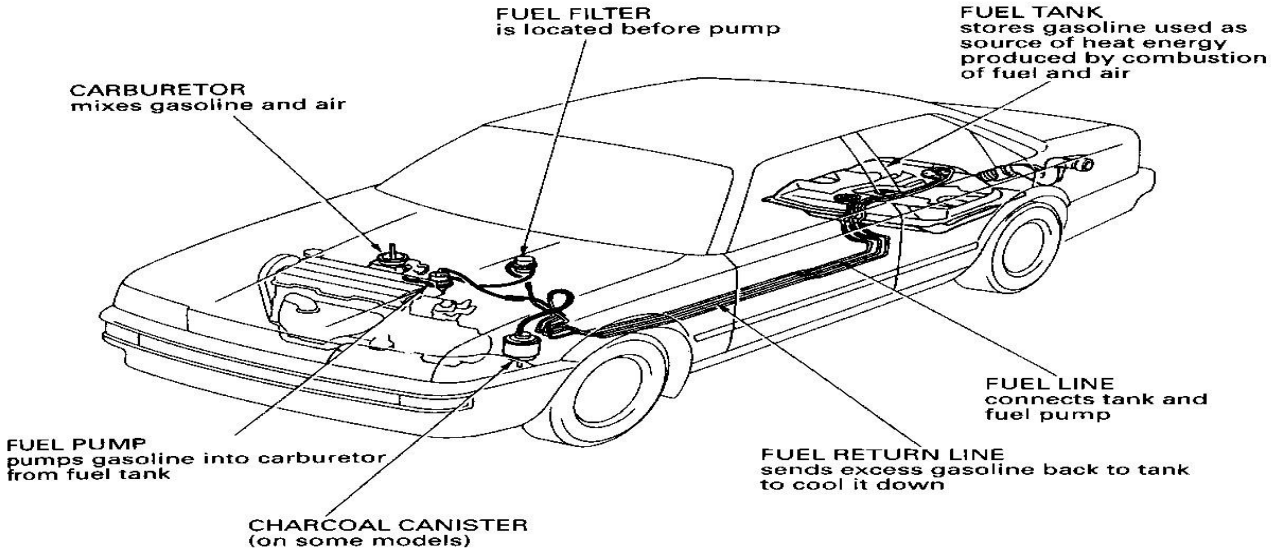


Figure 1 mounted system part location

The purpose of the fuel supply system for a petrol engine is to store, transfer and filter the petrol required by the float chamber of a carburetor. The most important components of this system are:

- Air cleaner
- Carburetor
- Fuel tank
- Charcoal canister (some models only)
- Fuel filter
- Fuel pump

Fuel line

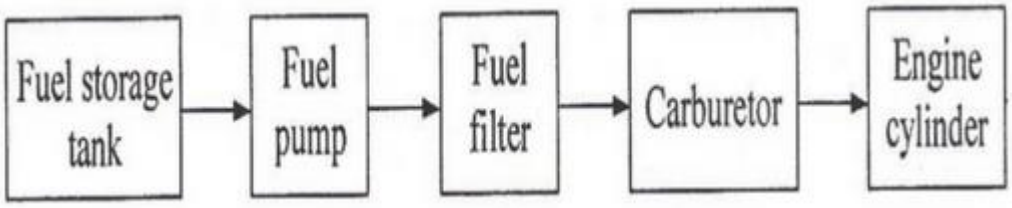


Figure 2 Figure Fuel system of spark ignition engine.

1.2. Gasoline Fuel System

In fuel supply system, air cleaners or air filters remove dust, dirt and other foreign particles present in the air and send clean air into engine cylinder. Fuel filters filter foreign particles that may be present in the fuel. A fuel pump lifts

fuel from the fuel tank and supplies to the carburetor through tubes and hoses (fuel lines). Correct quantity of air fuel mixture is supplied to the cylinder by carburetor. On some models, the HC (Hydrocarbon) gas generated in the fuel tank is temporarily absorbed in the charcoal canister and is burned in the engine. As a result, the amount of HC gas which leaks out of the fuel tank is reduced.

In some spark ignition engine, the fuel tank is placed above the level of the carburetor. The fuel flows from the fuel tank to the carburetor under the action of gravity. There are one or two filters between the fuel tank and the carburetor. A transparent sediment bowl is also provided to hold the dust and dirt of the fuel. If the tank is below the level of the carburetor, a lift pump is provided in between the tank and the carburetor for forcing fuel from the tank to the carburetor of the engine. The fuel comes from the fuel tank to the sediment bowl and then to the lift pump. From there the fuel goes to the carburetor through suitable pipe. From the carburetor, the fuel goes to the engine cylinder, through the inlet manifold of the engine.

1. CARBURETTOR:

The process of preparing an air-fuel mixture away from the cylinders of an engine is called carburetion and the device in which this process take place is called carburetor.

Principle of carburetor: The basic principle of all carburetor design that when air flows over the end of a narrow tube or jet containing liquid, some liquid is drawn into the air stream. The quantity of liquid drawn into the air stream increases as the speed of air flow over the jet increases and also the quantity is greater if the jet is made larger.

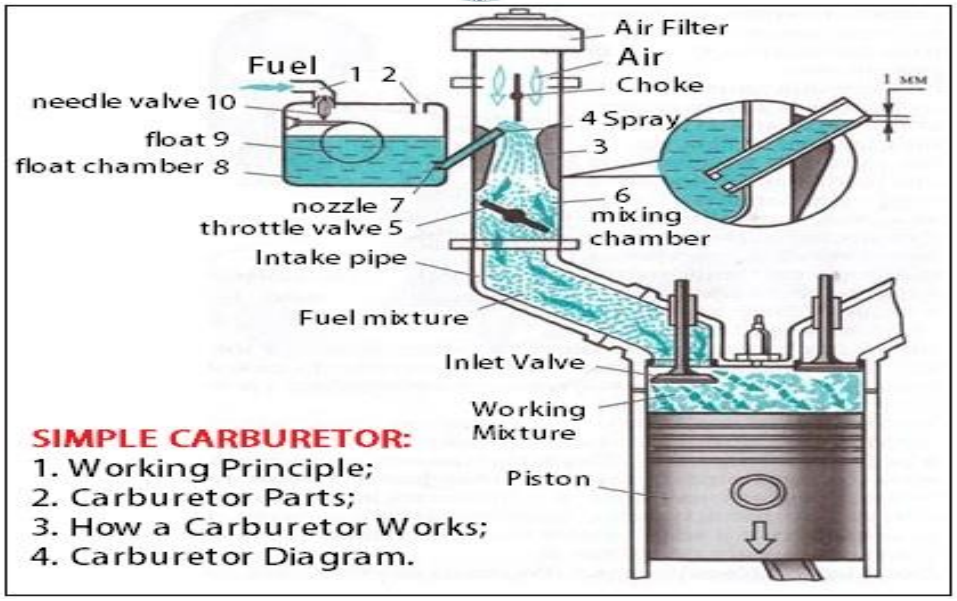


Figure 3 working principal

In practice, the fuel level in the jet is maintained by a float chamber. The fuel levels in the jet and in the float chamber are always the same. As the fuel is consumed, the level in the float chamber goes down. The float in the float chamber also goes down and the needle valve comes off its seat allowing more fuel into the chamber from the fuel tank. When the fuel level rises to its correct level, the float presses the needle valve back to its seat and cuts off the fuel flow. The velocity of the air flowing over the jet is increased by a constriction in the induction pipe known as venturi. A throttle butterfly valve provides an adjustable obstruction in the induction pipe. It is used to control the flow of air-fuel mixture to the engine. As the butterfly valve is turned into the accelerate position, the airflow over the jet increases and more fuel is drawn out into the air stream, keeping the mixture strength constant. A second butterfly valve called choke is used to provide a richer mixture for the engine to start in cold condition. The choke controls the volume of air entering into the venturi. A second jet is fitted near the throttle butterfly, which is used when the engine is idling. Fuel is delivered to the float chamber through fuel pipe either by gravity or by a pump. The float chamber is connected with the mixing chamber (venturi) via fuel nozzle equipped with fuel jet. Function of Carburetor: The main functions of the carburetor 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 and

(iv) To supply correct amount of mixture at different speeds and loads.

2. FUEL SYSTEM OF DIESEL ENGINE

During engine operation, the fuel is supplied by gravity from fuel tank to the primary filter where coarse impurities are removed. From the primary filter, the fuel is drawn by fuel transfer pump and is delivered to fuel injection pump through second fuel filter. The fuel injection pump supplies fuel under high pressure to the injectors through high pressure pipes. The injectors atomize the fuel and inject it into the combustion chamber of the engine. The fuel injection pump is fed with fuel in abundance. The excess fuel is by-passed to the intake side of the fuel transfer pump through a relief valve.

The main components of the fuel system in diesel engine are:

I. fuel filter
II. fuel lift pump
III. fuel injection pump
IV. atomizers and
V. high pressure pipe.

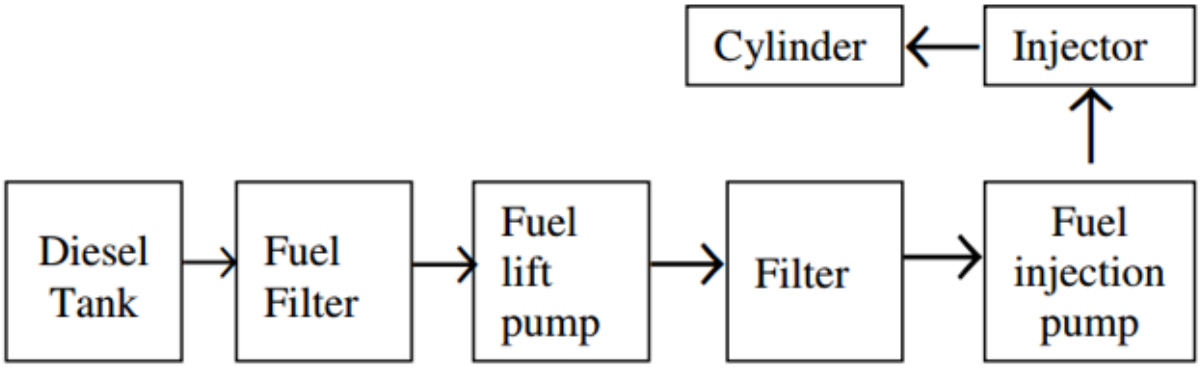


Figure 4 diesel fuel system flow diagram

Two conditions are essential for efficient operation of fuel system:

(i) The fuel oil should be clean, free from water, suspended dirt, sand or other foreign matter,

(ii) The fuel injection pump should create proper pressure, so that diesel fuel may be perfectly atomized by injectors and be injected in proper time and in proper quantity in the engine cylinder.

Fuel should be filtered before filling the tank also. If these precautions are followed, ninety per cent of diesel engine troubles are eliminated.

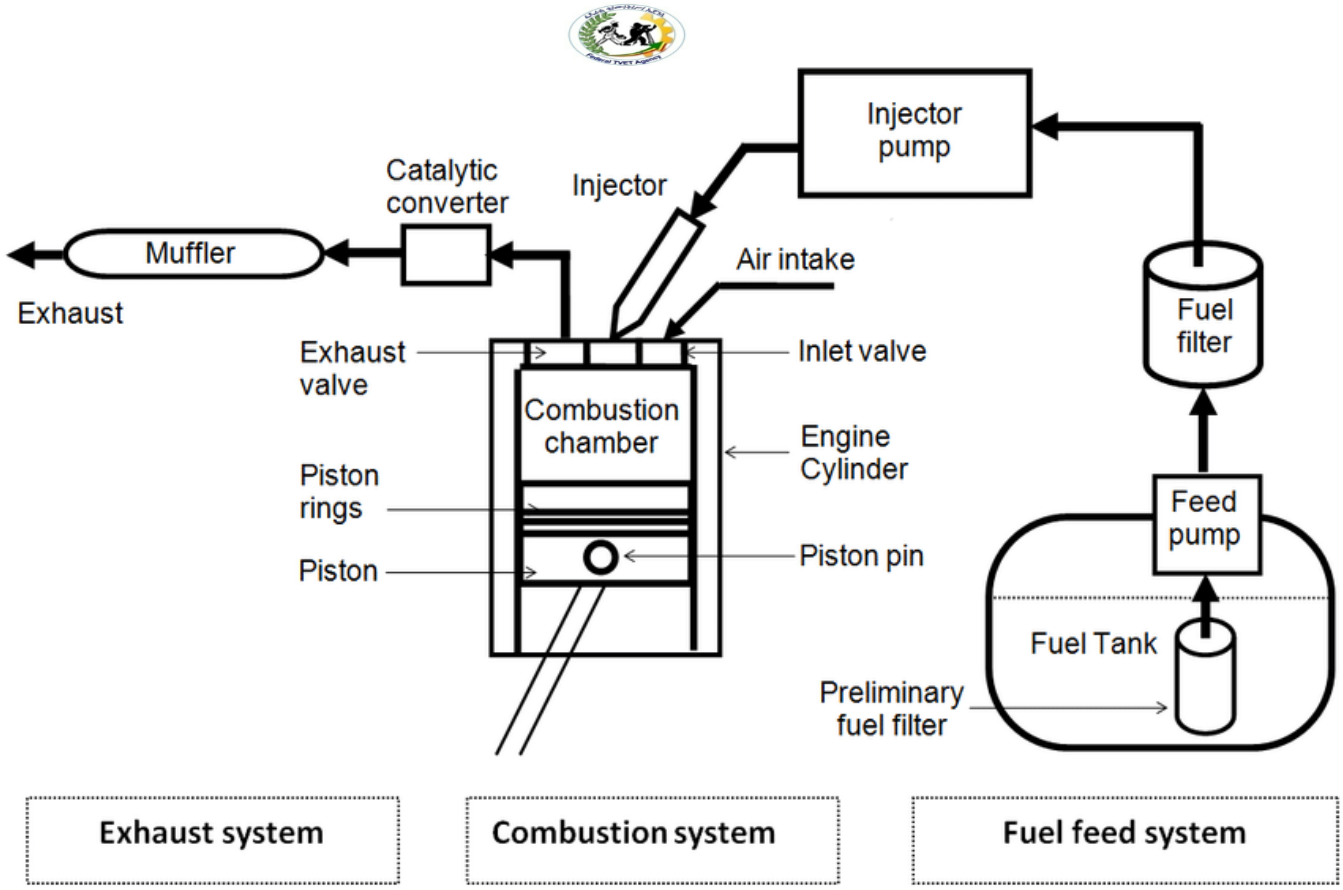


Figure 5 Figure Layout of fuel supply in diesel engine

3. FUEL INJECTION SYSTEM

Diesel fuel is injected in diesel engine through injectors with the help of fuel injection pump. The system using injectors, fuel injection pump, fuel filter, and fuel lines is called fuel injection system. The main functions of fuel injection system are:

(i) To measure 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.

Process of fuel injection in diesel engine is of two types:

(i) Air injection

(ii) Solid injection.

Air injection: In this process, the engine uses compressed air to force the fuel into the cylinder. It is a bulky system and hence it is not considered very suitable for vehicles and tractors. It is mostly used on heavy-duty stationary engines.

Solid injection: A high-pressure pump is used for forcing the fuel into the combustion chamber by using the fuel injection pump.

Functions of diesel fuel injection

The diesel: fuel injection system must

1. Supply the correct quantity of fuel.
2. Time the fuel delivery
3. Control the delivery rate. Smooth operation from each cylinder depends on the length of time it takes to inject the fuel. The higher the engine speed the faster the fuel must be injected.
4. Break-up or atomize the fuel
5. Distribute fuel evenly through the cylinder

4. Inline Fuel Injection Pump (Diesel)

Bosch In-line fuel injection pumps were first introduced in 1927. Since its introduction, it has kept countless number of diesel engines in function. In-line pumps are still widely used in large number of diesel engines, mainly because of its durability and ease of maintenance.

Requirements:

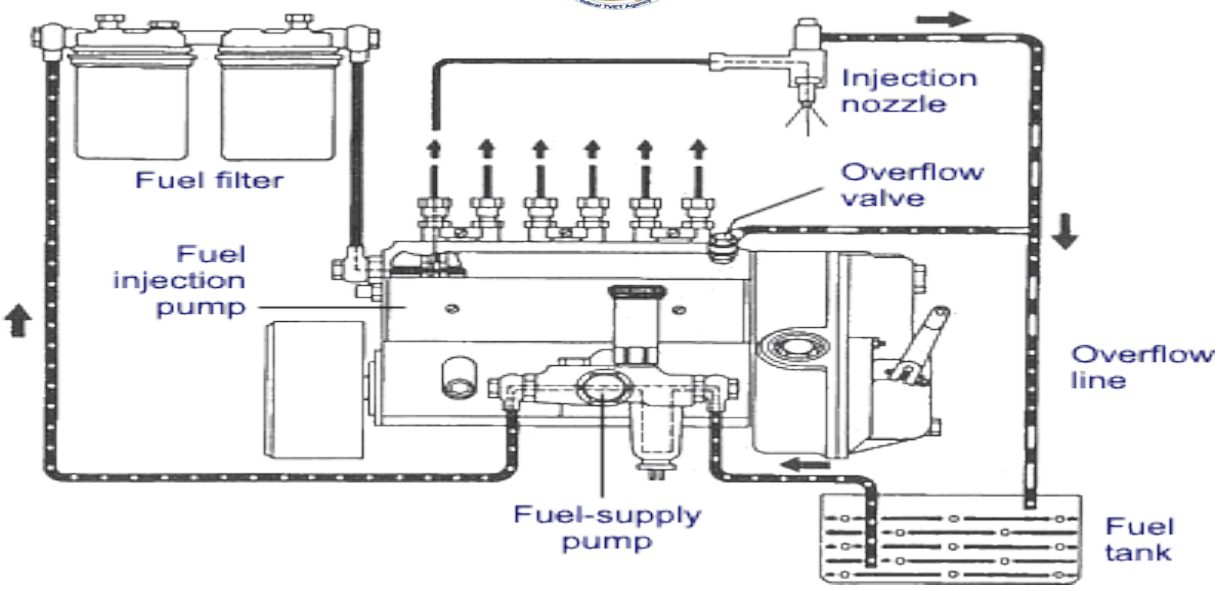
A fuel injection pump is used to supply fuel to the engine at a certain pressure. The pump generates the pressure and supplies the fuel with the right quantity at the desired timing. The pressurized fuel is delivered to the nozzle via a high pressure line. The nozzle injects the fuel inside the combustion chamber. There are various requirements to be met by a in-line pump, such as:

- Timing and duration of fuel injection
- The total volume of fuel to be injected
- The amount of pressure to be created

DESIGN:

The in-line fuel injection system consists of the following components:

- Fuel tank
- Feed pump to supply the fuel from fuel tank to the high pressure pump via a filter
- High pressure in-line pump to pressurize the fuel
- Nozzles to inject the fuel inside the combustion chamber
- Governor to vary the fuel quantity at varying speeds (usually a RSV governor)



5. Distributer type

1)COMPACT AND LIGHTWEIGHT WITH FEWER

PARTS: The four cylinder VE pump is slightly smaller than a four cylinder Incline pump, while the six cylinder VE pump is about half the size of a six cylinder Incline pump.

2)HIGH SPEED CAPABILITY: Engine speed of 5000rpm or greater may be achieved using the VE-type pump, while the upper limits of an engine using an inline type pump peak at around 4000rpm.

3)UNIFORM FUEL DELIVERY: By using a single plunger to distribute fuel to all the cylinders, less cylinder-to-cylinder variation is achieved. One advantage to uniform fuel delivery is the reduction of engine noise levels.

4)IMPROVED STARTING: A start spring (leaf type) in the pump acts to provide additional fuel when starting the engine. This feature facilitates engine starting in cold weather, especially when used on engines that incorporate a pre-combustion design.

5)IDLE STABILITY:

Uniform fuel delivery ensures stability and smoother engine idle speeds.

6)LUBRICATION:

The filtered diesel fuel that is supplied by the feed pump lubricates the internal working parts of the pump. This design eliminates the need for engine oil type lubrication of the injection pump.

7)EXTERNAL FUEL ADJUSTMENT:

Ease of adjustment is achieved by the external location of the maximum fuel delivery adjustment screw.

8)SHUT-OFF SOLENOID:

The fuel supply is shut-off by merely turning off the engine ignition switch.

9)COMBINED CAPABILITY: As a unit the VE pump incorporates the combined features of an injection pump, a feed pump, and a hydraulic timing device.

10)NON-REVERSING: Due to internal pump design the engine will not run in the reverse direction.

11)ADDITIONAL DEVICES: Several control devices may be fitted to the VE pump to achieve different fuel delivery characteristics as may be desired. (Automatic Cold Start Device, Load Sensing Timer, etc.)

12)VERSATILE MOUNTING: The VE pump may be mounted to an engine either horizontally or vertically.

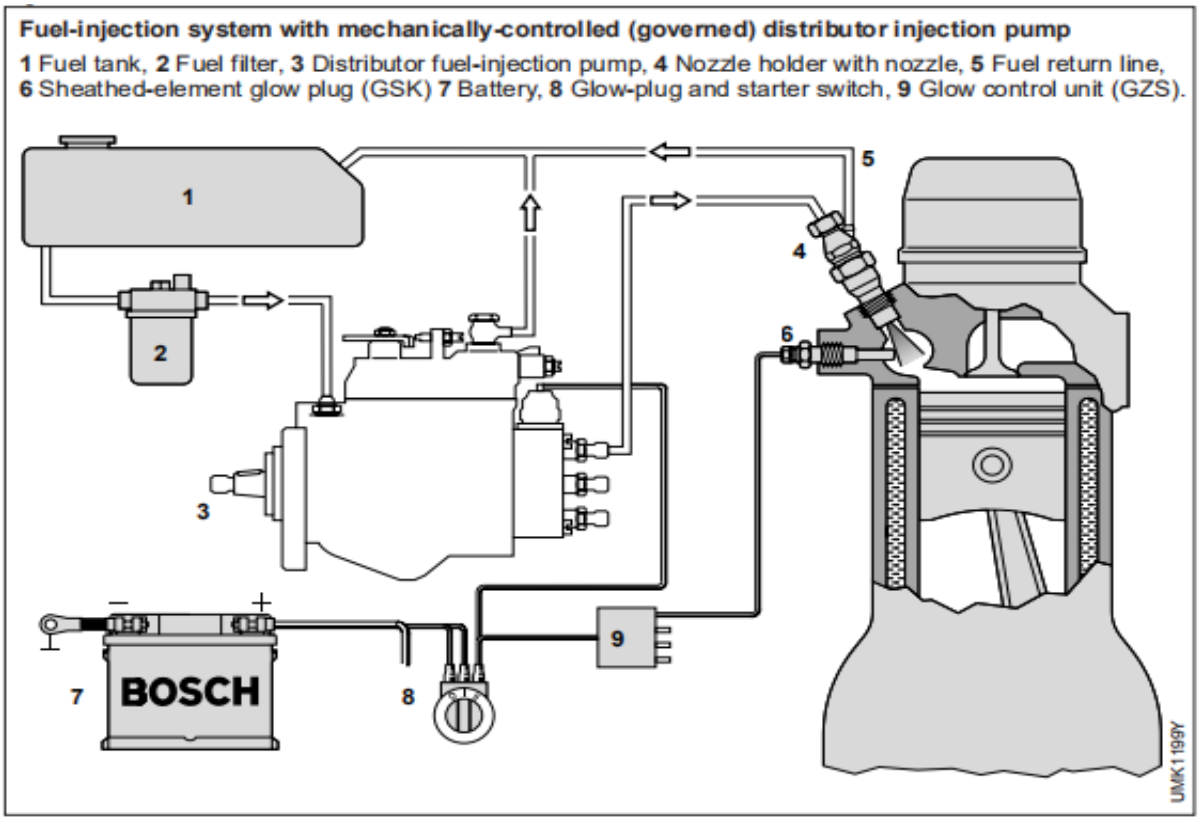


Figure 6 full diagram of diesel fuel system

Pump assembly with distributor head

Generates the high pressure and distributes the fuel to the respective fuel injector.
1 Yoke, **2** Roller ring, **3** Cam plate, **4** Distributor-plunger foot, **5** Distributor plunger, **6** Link element, **7** Control collar, **8** Distributor-head flange, **9** Delivery-valve holder, **10** Plunger-return spring, **4...8** Distributor head.

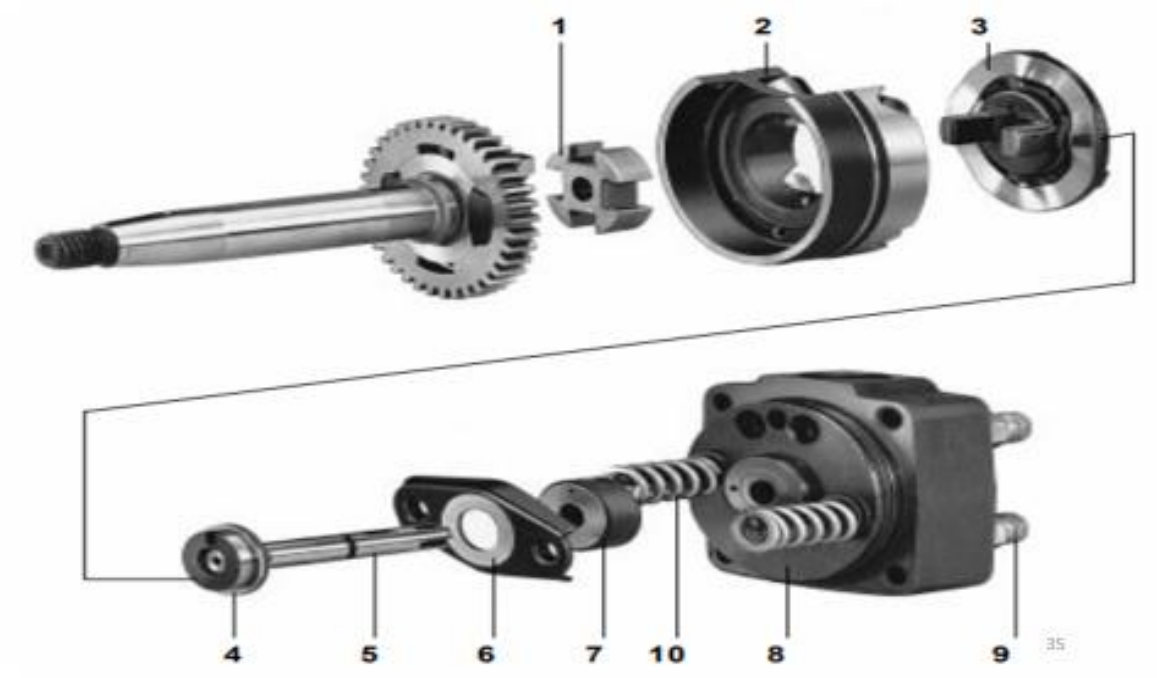
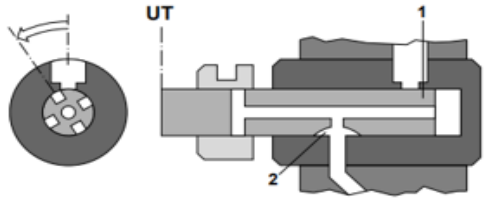


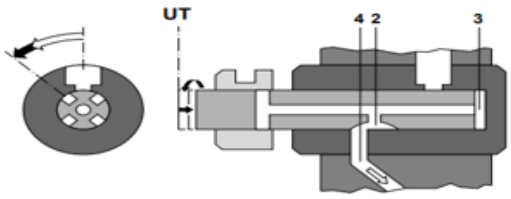
Figure 7 overhauled distributor injection pump

Distributor plunger with stroke and delivery phases

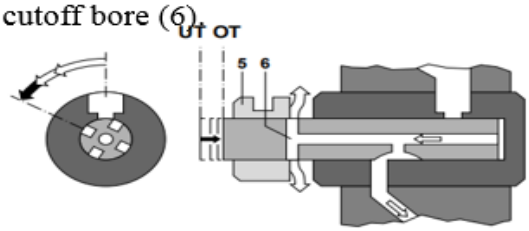
a Inlet passage closes.
At BDC, the metering slot **(1)** closes the inlet passage, and the distributor slot **(2)** opensthe outlet port.



b Fuel delivery. During the plunger stroke towards TDC (working stroke), the plunger pressurizes the fuel in the high_x0002_pressure chamber **(3)**. The fuel travels through the outlet-port passage **(4)** to the injection nozzle.



c End of delivery.
Fuel delivery ceases as soon as the control collar (5) opens the transverse cutoff bore (6).



d Entry of fuel. Shortly before TDC,the inlet passage is opened. During the plunger's return stroke to BDC, the high-pressure chamber is filled with fuel and the transverse cutoff bore is closed again. The outlet-port passage is also closed at this point.

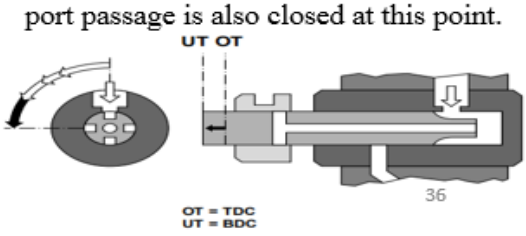


Figure 8 operating principle of the plunger

6. Air supply system

There are three purposes of the complete air supply system:

- clean the air;
- control air temperature;
- reduce noise.

A filter does the air cleaning and drawing air from around the exhaust manifold helps to control air temperature. When large quantities of air are drawn into the engine, it causes the air to vibrate and this makes it noisy. In the same way as with the exhaust system, baffles are used to stop resonance. Resonance means that when vibrations reach a natural level they tend to increase and keep going. A good example of how much noise is reduced by the air intake system is to compare the noise when an engine is run with the air filter removed. Two types of air filter are in use, the first of these being by far the most popular:

- paper element;
- oil bath and mesh.

The paper element is made of resin-impregnated paper. Air filters using this type of replaceable element are used for both car and commercial vehicles. They provide a very high filtering efficiency and reasonable service life. They can be mounted in any position available under the bonnet. Service intervals vary, so check recommendations. The oil bath and mesh type of air cleaner was widely used on non-turbo charged commercial vehicles. However, it is not very practical for modern low styled bonnets. Because it can be cleaned and fresh oil added, an oil bath air cleaner might still be used for vehicles operating in dusty conditions.

7. TURBOCHARGED DIESELS

A turbocharger greatly increases engine power by pumping additional compressed air into the combustion chambers. This allows a greater quantity of fuel to be burned in the cylinders, resulting in greater power output. In a turbocharger, the turbine wheel spins as exhaust gas flows out of the engine and drives the turbine blades. The turbine spins the compressor wheel at the opposite end of the turbine shaft, pumping air into the intake system.

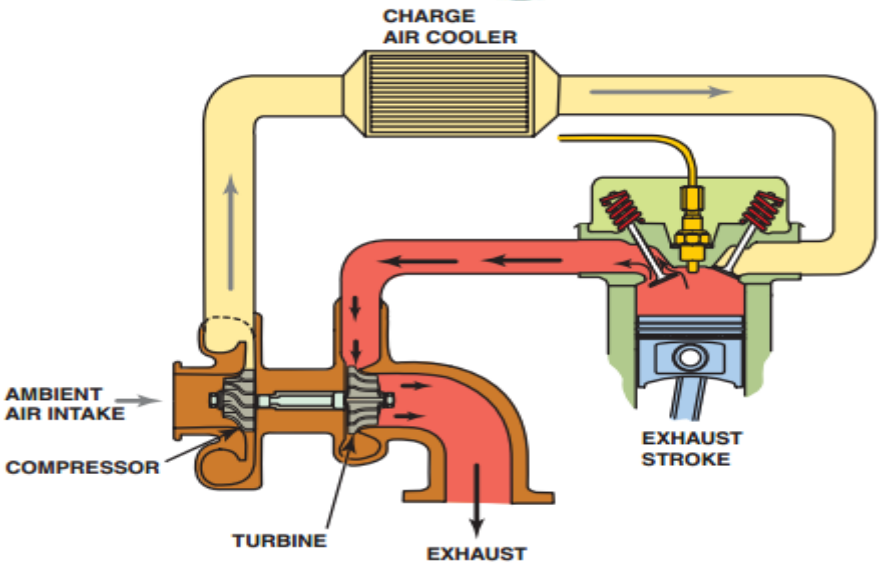


Figure 9 turbo charger with system installation

8. SUPERCHARGER

supercharger is an engine-driven air pump that supplies more than the normal amount of air into the intake manifold and boosts engine torque and power. A supercharger provides an instantaneous increase in power without any delay. However, a supercharger, because it is driven by the engine, requires horsepower to operate and is not as efficient as a turbocharger.

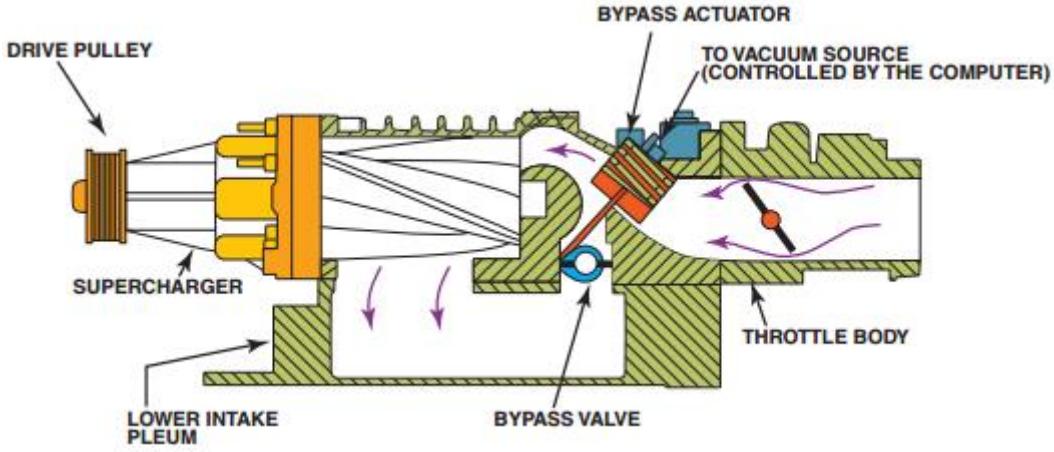


Figure 10 The bypass actuator opens the bypass valve to control boost pressure.

Self-Check 1	Written Test

Instruction: - chose and write the letter of the correct answer on the space provided or on the separate answer sheet (2 pts)

1. Which one of the following is not the types of fuel injection system?
   B. Inline
   C. Distributor
   D. Fuel filter
   E. A & B
2. Which one of the following is only part of the diesel fuel system?
   A. pump
   B. Glue plug
   C. Fuel filter
   D. All

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

1 _____

2.1. Fuel Conservation Practices

The efficiency of the engine can affect the fuel economy. Perkins design and technology in manufacturing provides maximum fuel efficiency in all applications. Follow the recommended procedures in order to attain optimum performance for the life of the engine.

• **Avoid spilling fuel.** Fuel expands when the fuel is warmed up. The fuel may overflow from the fuel tank. Inspect fuel lines for leaks. Repair the fuel lines, as needed.

• Be aware of the properties of the different fuels. Use only the recommended fuels.

• Avoid unnecessary idling. Shut off the engine rather than idle for long periods of time.

• Observe the air cleaner service indicator frequently. Keep the air cleaner elements clean.

• Maintain the electrical systems. One damaged battery cell will overwork the alternator. This will consume excess power and excess fuel.

• Ensure that the drive belts are correctly adjusted.

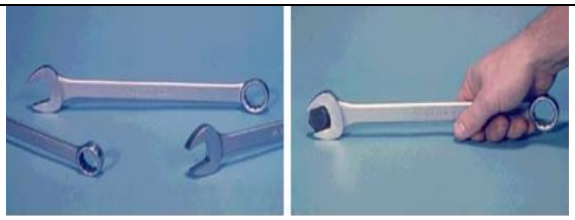
The drive belts should be in good condition.

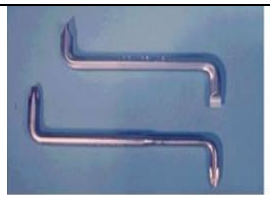
• Ensure that all of the connections of the hoses are tight. The connections should not leak.

• Ensure that the driven equipment is in good working order.

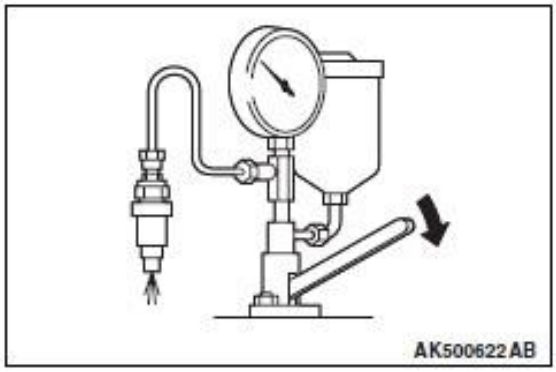
• Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.

2.2. Hand Tools

The combination wrench/spanner has open-end jaws on one end and the closed box socket on the other end.	

The ferrule nut wrench/flare nut spanner is similar in appearance to a standard box end wrench, except for the slot in the end and the heavier jaws, designed to loosen and tighten ferrule nuts on fuel injection lines.	 
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	
The Phillips screwdriver consists of a length of round tool steel bar stock with a handle on one end and a ground four-point tip on the other end.	 
A flat screwdriver consists of a length of round or square tool steel bar stock with a handle on one end and a tapered blade on the other end.	
Offset screwdrivers consist of a short length of round or hexagonal tool steel bar stock with a driving blade or tip at each end at a 90 degree angle to the handle.	 
Needle nose pliers range in size from two to six inches in length for most common applications.	 

2.3. Testing equipment

Pressure gauge is used to measure the pressure of the fuel.	
Injector Tester used to test the injector Nozzle.	
Test bench it's have 12 cylinders with motor, can be test both in-line and rotary fuel injection pumps, for example, A, B, P, Z, VE pumps and so on, by employing the suitable accessories. It displays speed, counting, test oil temperature, pressure/vacuum and advance angles.	

Self-Check 3	Written Test

Instruction: - chose and write the letter of the correct answer on the space provided or on the separate answer sheet (2 pts)

1. Which tools we use to lose the carburetor?

A. Flat fillips screw driver

B. open end wrench

C. socket wrench.

D. All of the above

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

1 _____

3.1. Removing air from the fuel System

Couse If air enters the fuel system; the air must be purged from the fuel system before the engine can be started. Air can enter the fuel system when the following events occur:

- The fuel tank is empty or the fuel tank has been partially drained.
- The low pressure fuel lines are disconnected.
- A leak exists in the low pressure fuel system.
- The fuel filter is replaced.
- A new injection pump is installed.

3.1.1. Use the following procedure in order to remove air from the fuel system:

A. Ensure that all fuel connections are installed correctly.

B. Turn the key switch to the RUN position. Leave the key switch in the RUN position for three minutes. If a manual purging screw is installed, slacken the manual purging screw during priming the fuel system.

C. Crank the engine with the throttle lever in the closed position until the engine starts.

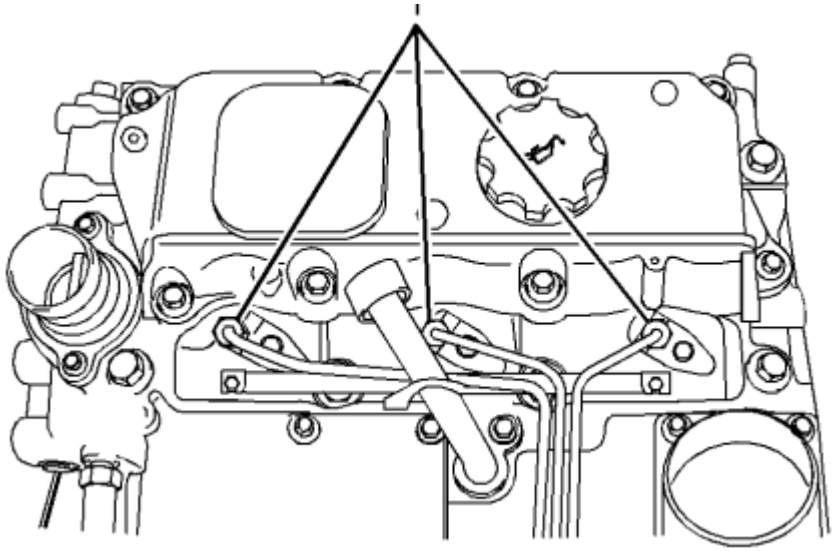


Figure 11 bleeding location

Note: If necessary, loosen the union nuts (1) on the fuel injection lines at the connection with the fuel injector until fuel is evident. Stop cranking the engine. Tighten the union nuts to a torque of 27 NM (20 lb. ft.).

D. Start the engine and run the engine at idle for one minute.

E. Cycle the throttle lever from the low idle position to the high idle position three times. The cycle time for the throttle lever is approximately one second to six seconds for one complete cycle.

Note: In order to purge air from the fuel injection pump on Perkins engines with a fixed throttle, the engine should be run at full load for thirty seconds. This should be repeated three times. This will assist in removing trapped air from the fuel injection pump.

F. Return the engine to no load condition. Check for leaks in the fuel system.

Self-Check 3	Written Test

Instruction: - chose and write the letter of the correct answer on the space provided or on the separate answer sheet (2 pts)

1 Removing air in the system is keep engine from?

A. Abnormal running

B. Shut off.

C. Power lose

D. All of the above

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

1 _____

4.1. Fuel Delivery Rate Calibration

- As discussed earlier, the amount of fuel delivery by each pumping plunger must be equal to provide even firing and smooth operation.
- The amount of fuel delivered by a individual pumping element is controlled by its effective stroke.
- This is the time during its lift stroke that both inlet ports in the barrel are closed.
- Plunger rotation by the fuel control rack causes the helix to either lengthen or shorten the effective stroke
- For a given amount of control rack movement,
- the change in the effective stroke must be the same for all plungers.
- If it is not, the fuel rate must be adjusted at each plunger.
- Measuring the rate of fuel delivery and the effect control rack movement has on it can only be done on a fuel pump test.
- Test stands measure the delivered volume of fuel from each barrel and plunger assembly through the use of video display monitoring, or by graduated cylinders,
- The injection pump is mounted to the stand, and each individual pumping element is checked in the engine's firing order.
- Variations between the fuel delivery rates indicate that adjustment is needed to bring all elements into manufacturer's specifications.
- The exact adjustment procedure varies depending on inline pump design.
- On some pumps, the fuel rate adjustment is made by loosening the control sleeve on the control rack.
- By inserting a small punch pin into the radial holes on the sleeve, it can be rotated clockwise or counter-clockwise to change the pumps delivery rate.
- On pumps that use bolted barrel flanges on top of the injection pump housing,
    - the adjustment is made by loosening the barrel flange retaining nuts and rotating the flange either clockwise or counter-clockwise.
    - This alters the control fork position

- Most pumps provide approximately 10^0 of barrel rotation for setting the fuel delivery rate.
- The test stand must be run at specified speeds per the pump manufacturer's test specifications.
- Mount the pump on the test stand and be certain there is adequate clearance at the drive coupling.
- Connect the fuel supply line to the pump inlet and the lines to the valve holders.
- Also connect the lubrication line from the test stand to the pump
- If the pump is not engine oil lubricated, fill the pump sump with the appropriate lubricating oil.
- Refer to the appropriate pump manufacturer specification sheet and
    - set the number 1 sIeeve gear or control fork to specifications
    - Some pump specifications call for calibrating the number 6 element first
- Select the correct, pump drive direction (counter-clockwise or clockwise).
- Open the fuel supply valve to pressure flow and loosen the 1 pump bleed screw and start the pump drive.
- Operate the pump until all air has been bled from the system, and then tighten the bleed screw.
- The first step is to adjust the maximum fuel delivery from the first element (number 1 or 5 as specified).
    - Move f the fuel lever to the maximum speed position.
    - Run the pump at the specified speed and
    - note the delivery from the element for the specified number of shots
    - Adjust the maximum fuel stop screw until the maximum delivery is as specified.
    - Repeat the test several times to ensure accuracy
- Now adjust the position of the other sleeve gears or control forks
    - so that the maximum delivery rate from their -pumping elements is exactly the same as that from the specified element.
- Check the operation of the excess fuel device and fuel stop control.

4.2. Final Checks

- Adjust the control rack stops as described earlier in the chapter.

- Check fuel delivery rates at the excess fuel position and at idle.
- After calibration is complete, install all plugs, covers, etc.,
- using new gaskets and sealing washers as needed.
- Install tamper-proof locks and seals as specified.

Self-Check 4	Written Test

Instruction: - write true if the statement is correct or write false if the statement is incorrect and write the answer on the space provided or on the separate answer sheet (2 pts)

1. The amount of fuel delivered by a individual pumping element is controlled by its effective stroke
2. the change in the effective stroke must be the same for all plungers

9.

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

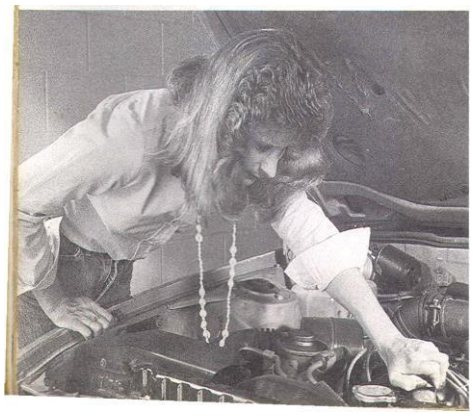
1 _____2 _____

5.1. Guidelines for Safely Working On Fuel Systems

- Always wear eye protection and follow all other safety rules to prevent injury to yourself or others when servicing fuel systems.
- When working on a fuel system in the engine compartment, disconnect the negative cable of the battery. An electrical spark may cause a fire or explosion.
- Slowly remove the fuel filler cap. If the cap is venting vapor or if you hear a hissing sound, wait until it stops before completely removing the cap.
- Do not smoke when working on or near any fuel related component.
- Do not allow heat or flames to be near while working on or near the fuel system.
- Remove all electronic devices, such as cell phones, pagers, and audio equipment, from your clothing when working on or near the fuel system.
- Clean all fuel spills immediately; spilled fuel may be ignited by hot components.
- If a fuel line or hose is damaged in any way, replace it.
- When disconnecting or reconnecting a fuel line or hose, make sure that the mating parts are totally clean.
- After disconnecting a fuel line or hose, plug both ends to prevent dirt from entering.
- When disconnecting and reconnecting a fuel line or hose, only use the tools designed for that connection. Using the wrong tool can cause a poor connection that can result in a fuel leak.
- When a fuel line that has pressurized fuel in it is loosened, the fuel will spray uncontrollably as soon as it can. The fuel can spray on something hot and cause a fire or spray into your eyes and cause a serious injury.
- Never smoke while working on a car/any machine in the shop

- Keep your skin away from hot parts, such as radiator, exhaust manifold, tail pipe, catalytic converter, and muffler

- Always disconnect electric cooling engine cooling fans when working around the radiator, and reconnect the fan after you have completed your repair job.
- Properly store all parts and tools in a safe place
- Remove all jewelry (rings, necklaces, bracelets, and watches) o Because a ring can rip a finger off o A watch can cut a wrist o A necklace can choke a person, etc.
- Be sure to relieve the fuel pressure before fuel pump or fuel hose removal.



- Bending or twisting the control cables will affect operation and could cause the cables to stick or bind, resulting in loss of vehicle control.
- Work in a fully ventilated area. Smoking or allowing flames or sparks in the work area or where gasoline is stored can cause a fire or explosion.
- Do not loosen or tighten the painted bolts and screws of the throttle body. Loosening or tighten them can cause throttle and idle failure.
- Seal the cylinder head intake ports with tape or a clean towel to prevent dirt and debris from entering the intake ports after the throttle body has been removed.

5.2. Use of firefighting equipment

Types of fire extinguisher

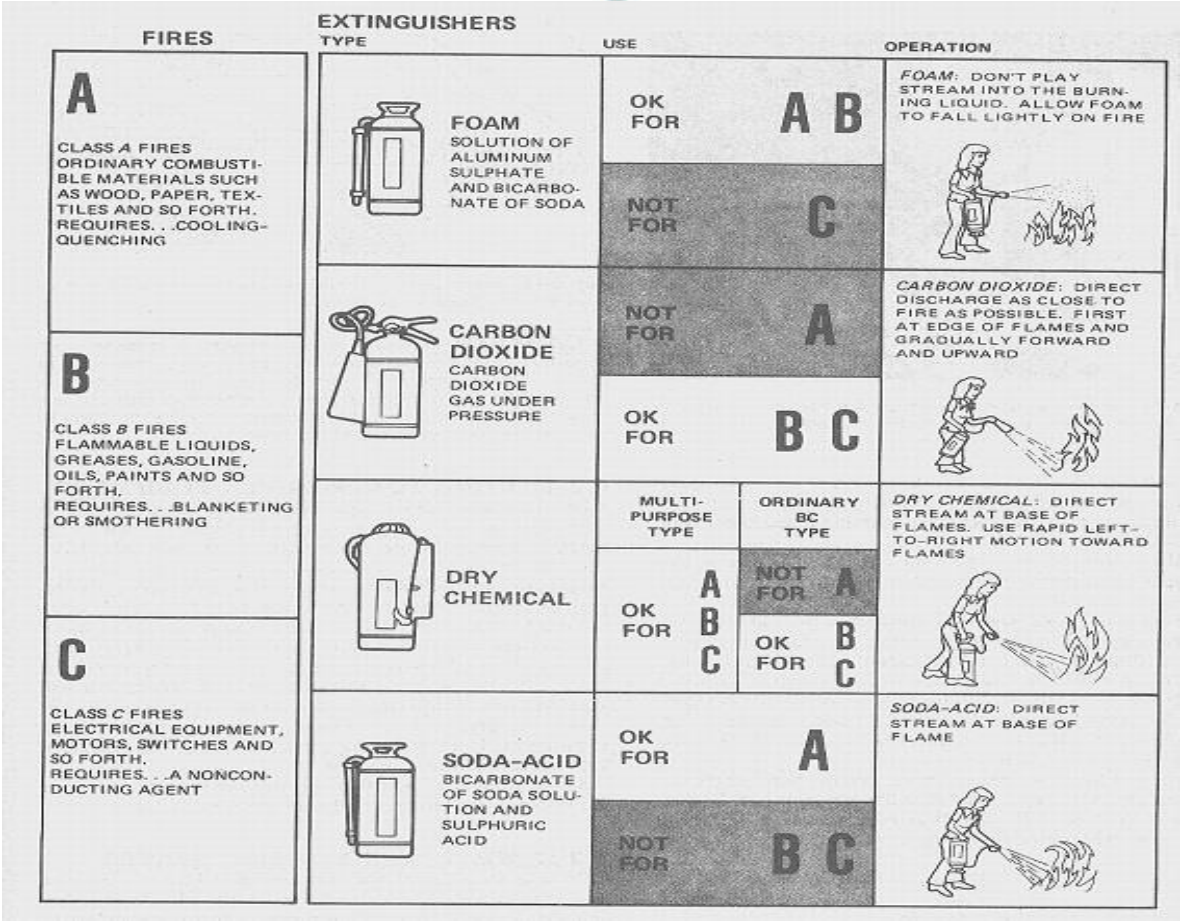


Figure 12 Types of fire extinguisher

Self-Check 5	Written Test

Instruction: - write true if the statement is correct or write false if the statement is incorrect and write the answer on the space provided or on the separate answer sheet (2 pts)

1. Class A fire includes liquid flammable materials
2. Working on the vehicle with wearing jewelry is not risky

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

1 _____

Information Sheet-6 Sourcing and observing applicable national environmental protection measure/ guidelines

6.1. Environmental Factors

Ambient temperatures – The engine may be exposed to extended operation in extremely cold environments or hot environments. Valve components can be damaged by carbon buildup if the engine is frequently started and stopped in very

cold temperatures. Extremely hot intake air reduces engine performance.

Quality of the air – The engine may be exposed to extended operation in an environment that is dirty or dusty, unless the equipment is cleaned regularly. Mud, dirt and dust can encase components. Maintenance can be very difficult. The buildup can contain corrosive chemicals.

Buildup – Compounds, elements, corrosive chemicals and salt can damage some components.

Altitude – Problems can arise when the engine is operated at altitudes that are higher than the intended settings for that application. Necessary adjustments should be made.

6.2. Incorrect Operating Procedures

- Extended operation at low idle
- Frequent hot shutdowns
- Operating at excessive loads
- Operating at excessive speeds
- Operating outside the intended application Incorrect Maintenance Procedures
- Extending the maintenance intervals
- Failure to use recommended fuel, lubricants and coolant/antifreeze

6.3. Warranty Information

Emissions Warranty

This engine may be certified to comply with exhaust emission standards and gaseous emission standards that are prescribed by the law at the time of manufacture, and this engine may be covered by an Emissions Warranty. Consult your authorized Perkins dealer or your authorized Perkins distributor in order to determine if your engine is emissions certified and if your engine is subject to an Emissions Warranty.

Self-Check 6	Written Test

Instruction: - choose and write the letter of the correct answer on the space provided (2 pts)

1. Incorrect Operating Procedures is including
   A. Extended operation at low idle
   B. Frequent hot shutdowns
   C. Operating at excessive loads
   D. Operating at excessive speeds
   E. All of the above

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

1 _____

Operation sheet 1 final calibration

Calibration

The first step is to adjust the maximum fuel delivery from the first element.

- Move the fuel lever to the maximum speed position.
- Run the pump at the specified speed and
- note the delivery from the element for the specified number of shots
- Adjust the maximum fuel stop screw until the maximum delivery is as specified.
- Repeat the test several times to ensure accuracy

Final Checks

- Adjust the control rack stops as described earlier in the chapter.
- Check fuel delivery rates at the excess fuel position and at idle.
- After calibration is complete, install all plugs, covers, etc.,
- using new gaskets and sealing washers as needed.
- Install tamper-proof locks and seals as specified.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Task 1: make fuel system final check

Task 2- check fuel delivery

LG #28	LO #2- Prepare to carry out engine overhaul

Instruction sheet

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

- Implementing methods for conducting diesel and gasoline fuel injection system tests
- Comparing test results with manufacturer specifications
- Documenting results with evidence and supporting information
- Forwarding report to appropriate persons

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

- Implement methods for conducting diesel and gasoline fuel injection system tests
- Compare test results with manufacturer specifications
- Document results with evidence and supporting information
- Forward report to appropriate persons

Learning Instructions:

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

1. conducting diesel and gasoline fuel injection system tests

1.1. Fuel pump test

1.1.1. Testing delivery pressure

The pressure gauge with three-way tap is to be inserted between the carburetor and the fuel pump in such way that the delivery pressure can be measured in various operating situations. The pressure should be between 0.1 and 0.25 bar depending on engine type. after this measurement, the engine is stopped, where upon the pressure should not drop too rapidly. If it does, the three-way tap must be result until the carburetor receives no further fuel and the fuel pump delivers only against the pressure gauge of the tester. the engine should then be stopped again. if the pressure still drops rapidly, the pump leaking.

1.1.2. Checking suction

If the delivery pressure test does not yield satisfactory result, the suction performance of the fuel pump must be checked to determine whether the fault is in the pump or in the supply line between the fuel tank and the pump. two tests are needed.

Detach fuel supply from the fuel pump and connect vacuum tester in its place. start the engine and adjust it to the correct idle speed. if the specified maximum value is shown on the vacuum tester, stop the engine and check that the vacuum reading remain constant for about 30 second. If it does the valves and diaphragm of the fuel pump are in good condition.

To check the fuel supply line, reconnect it to the fuel pump but attach the other end to vacuum reading falls away rapidly, but the fuel pump has been provided to be in condition, the leak must be in the fuel supply line.

1.2. Test and Inspection (for In-line Injection Pump system)

1.2.1. Standard Fuel Feed Volume

The volume of fuel displaced by the pump is more than 300ml for each 15 seconds at 1000rpm.

The discharge pressure is more than 157kPa (1.57bar, 1.6kg/cm2, 23psi) per 30 seconds at 600rpm.

1.2.2. Feed Pump performance test:

1. Connect a pipe to the intake side of the feed pump, and set pump fuel level 1.0m (3.3ft) below the pump.

2. Operate priming pump at 60 strokes per minute, and make sure that fuel can be sucked up within 1 minute.

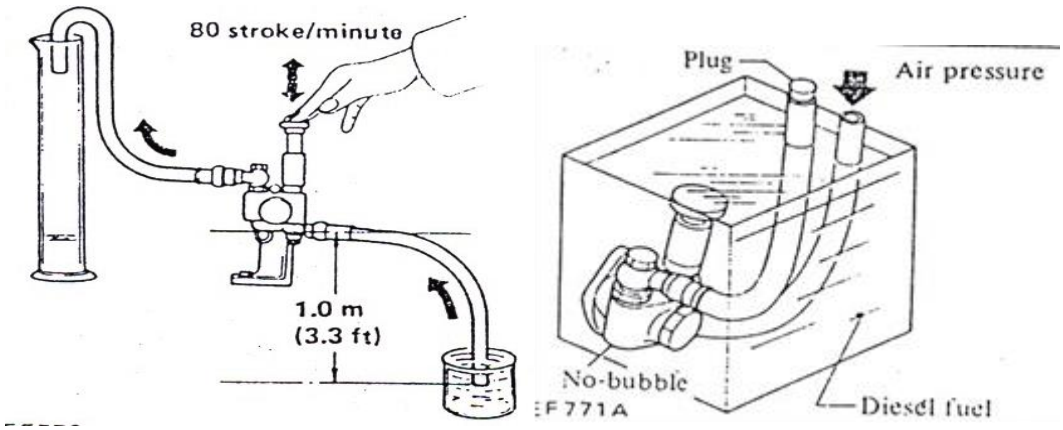


Figure 13 Air tightness

Figure 14 Performance test

Air-tightness test:

1. Stop up fuel discharge port and apply 147 to 196 kPa (1.47 to 1.96 bar, 21-28psi) of air pressure to intake side of pump.
2. Immerse pump in Kerosene (Diesel Fuel) and make sure that no air leaks from any of pump connections. If bubbles larger than one grain come from fuel pump housing or push rod joint continuously, replace oil seal at push rod or push rod. Replace feed pump assembly if necessary.

1.3. INSPECTION

1.3.1. Feed Pump Housing:

A. Check valve seats. If they are damaged or excessively worn eplace the housing.

B. Check push rod hole. If hole is excessively worn, replace housing.

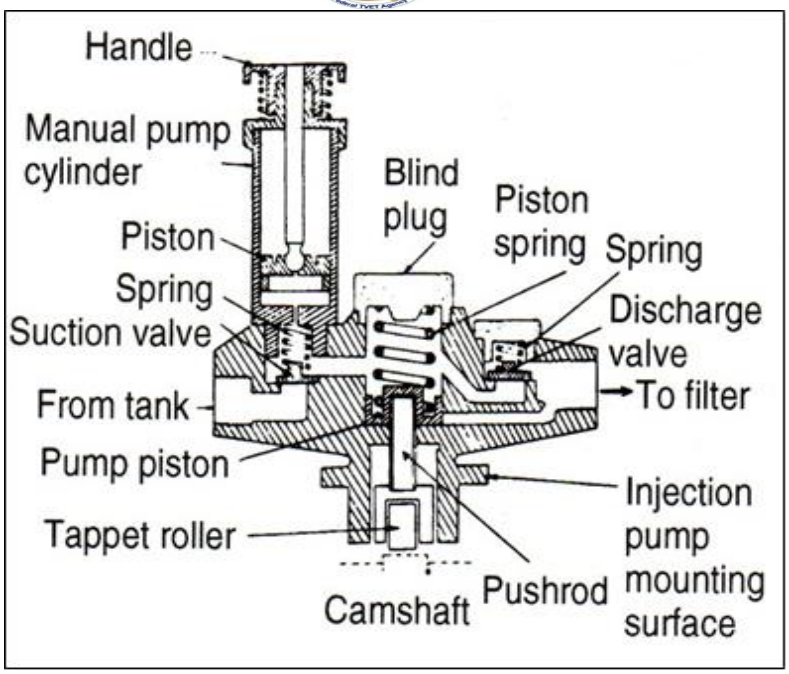


Figure 15 feed pump section view

1.3.2. Check valve and check valve spring:

1. If seat of check valve is excessively worn or scarred, replace check valve with a new one.
2. If check valve spring is damaged or permanently stressed, replace valve spring.

1.3.3. Piston and piston spring:

1. If periphery of piston is excessively worn or scarred, replace piston with a new one.
2. If piston spring is damaged or weakened, replace valve spring.

1.3.4. Tappet assembly:

1. Tappet. If periphery of tappet is worn or scarred, replace it with a new one.
2. Tappet roller. If periphery of tappet roller is excessively worn or scarred, replace it with a new one.

   Roller to Pin Clearance: Limit – 0.30mm (0.0118 in.)

   Tappet roller outside diameter: Wear limit – 14.9mm (0.587 in)

1.4. Drain Water from fuel filter:

Drain water from fuel filter in accordance with maintenance schedule. Also do this when warning light comes on.

1. Disconnect fuel filter sensor harness.
2. Loosen fuel filter sensor and drain water.
   a. Be sure to place a container beneath the fuel filter.

b. Pumping priming pump will quicken water drainage.

3. When fuel overflows, re -tighten and connect fuel filter sensor.

1.5. BLEEDING THE FUEL SYSTEM

It will be necessary to bleed the fuel system to achieve a steady air free-flow of fuel if any of the following have occurred.

1) Running out of fuel.

2) If fuel shut off valve is left closed and engine runs out of fuel.

3) Replacing fuel filter.

4) Fuel injector nozzle or injector pump repair/service.

5) After repairing or replacing any fuel line.

6) Replacement of electric or mechanical fuel pump.

7) Any time air is permitted to enter the fuel system.

Self-Check 1	Written Test

Instruction I: - chose and write the letter of the correct answer on the space provided or on the separate answer sheet (2 pts)

1 The purpose of the testing in the fuel system isto ?

A. Identifies problem

B. Service the problem

C. Replace the component.

D. All of the above

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

1 _____

2.1 Diesel Injector Nozzle

The main functions of a Diesel fuel injector are:

- to ensure that the diesel fuel is injected into the engine's combustion chamber at the correct pressure, and to form the correct spray pattern;
- to stop the injection of the fuel as soon as the injection. Pump pressure drops below a pre-set level.

Inside a fuel injector nozzle is a needle valve, which has been machined to very fine tolerances. The needle valve is held tight on its seat by an injector spring and spindle. Directly below the needle valve and seat is the nozzle tip, which directs the fuel into a predetermined spot within the combustion chamber. When the fuel pressure is low, the needle valve is held tightly onto its seat by spring pressure.

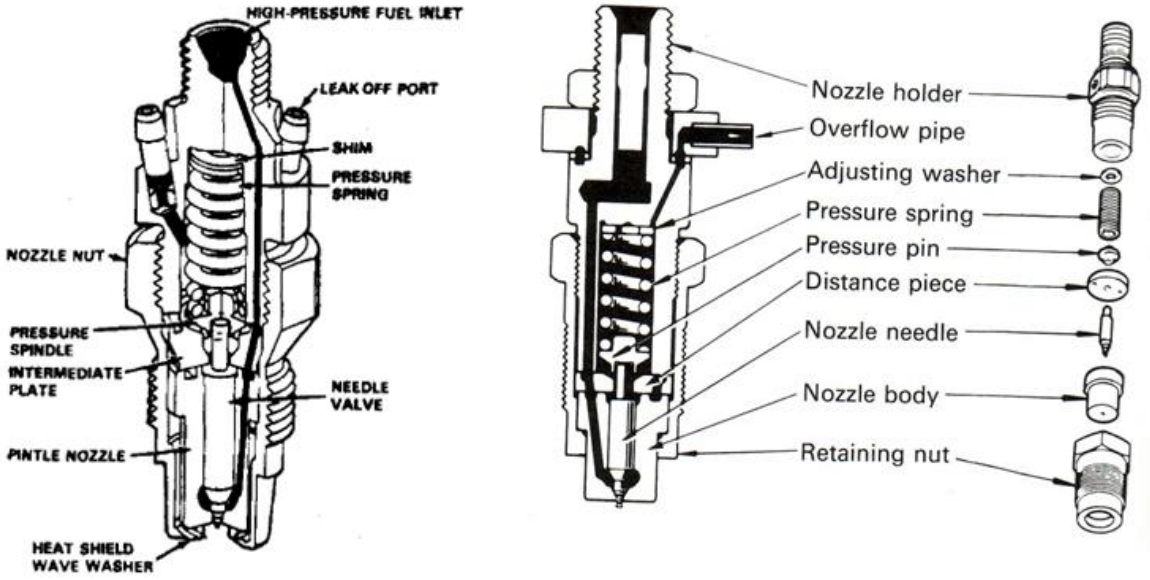


*Figure 16 injector **nozzle***

2.2 Operation:

a) Before Injection

The highly pressurized fuel flows from the injection pump through the oil passage in the nozzle holder to the oil pool at the bottom of the nozzle body.

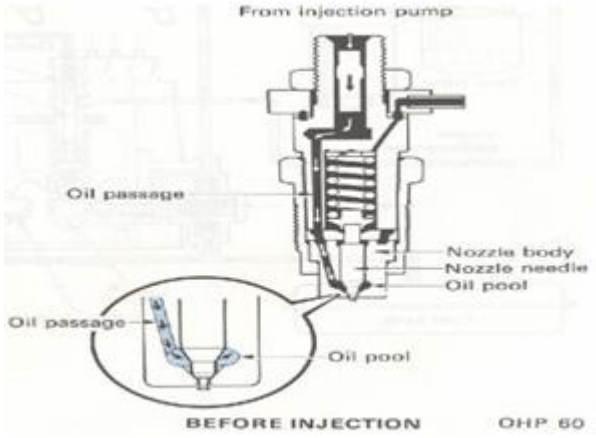


Figure 17 before injection

b) Fuel Injection

As the pressure of the fuel in the oil pool increases, it pushes on the end surface of the nozzle needle with increasing force. When this force becomes greater than the force of the pressure spring, the nozzle needle is pushed up by the fuel pressure and the needle separates from the nozzle body seat. This allows the nozzle to spray the fuel into the combustion chamber.

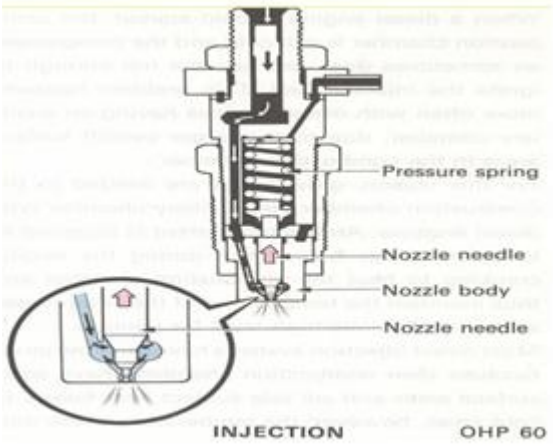


Figure 18 during injection

c) End of Injection

When the injection pump stops supplying fuel, the fuel pressure drops and the pressure spring returns the nozzle needle to its initial position. The needle is now tightly pressed against the nozzle body seat and blocks the fuel passage, thus ending fuel injection.

A part of the fuel exits between the nozzle needle and the nozzle body, between the pressure pin and the nozzle holder, etc., lubricating all components, and finally returns to the overflow pipe.

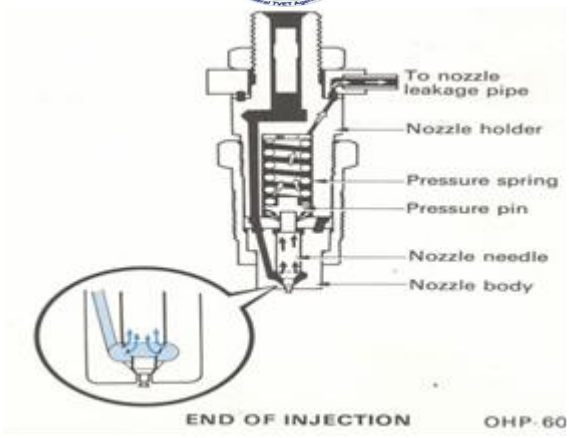
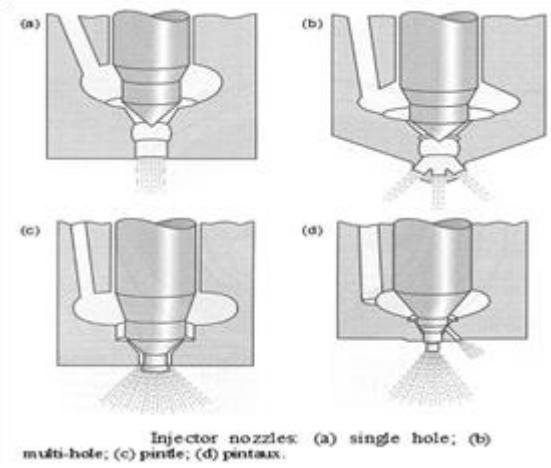


Figure 19 end of injection

2.3 There are four types of fuel injector:

a. Single-Hole Injector
b. Multi-Hole Injector
c. Pintle-Type Injector
d. Pintaux Injector



Injector nozzles: (a) single hole; (b) multi-hole; (c) pintle; (d) pintaux.

.figure 8. Types of injectors

The type of nozzle to be used is mainly determined by the combustion process and the shape of the combustion chamber. The multiple hole type is generally used for direct injection type engines, while the pin type is mainly used for pre combustion chamber and swirl chamber type engines.

2.4 Injector Maintenance

To ensure that the injector both atomizes the fuel and forms the correct spray pattern, it is necessary to check the opening or cracking pressure of the injectors periodically. The opening pressure is measured in bars or atmospheres. 1 atmosphere = 14.7Ibf/in2 or 101.3 kPa). For most injectors, the opening pressure will be in the range

125-175 bar.

The opening pressure of an injector can be tested using a hand-operated test unit, sometimes called a pop tester.

Note: Never remove an injection nozzle from the engine except for service or replacement.

The following indicate injection-nozzle trouble:

- One or more cylinder knocking.
- Loss of power.
- Smoky black exhaust.
- Engine overheating.
- Excessive fuel consumption.

1. One way to check injection nozzles is to run the engine at fast idle.
2. Loosen the connector at each nozzle in turn, one at a time.
3. Wrap a cloth around the connection before you loosen it to keep fuel from spurting out. If loosening the connector causes engine speed to drop, the nozzle is probably working normally. If the engine speed remains the same, the nozzle is not working properly. Clogged holes are preventing fuel delivery or causing an improper spray pattern. Some manufacturers recommend a spray test of the detached injection nozzle. This requires a nozzle tester, which is a special hydraulic pump and pressure gauge.
4. Attach the nozzle and apply pressure. The fuel should spray in an acceptable pattern when the specified pressure is reached.
5. Releasing the pressure should stop the spray abruptly without any drip from the nozzle.

Caution:

Direct the spray from the nozzle into a suitable container. Do not allow the spray to hit your skin. The pressure is high enough to force fuel oil through the skin. You can be seriously injured because the oil could cause an infection.

Self-Check 2	Written Test

Instruction: - chose and write the letter of the correct answer on the space provided or on the separate answer sheet (2 pts)

1 Which one of the following is types of injectors?

A. Single-Hole Injector
B. Multi-Hole Injector
C. Pintle-Type Injector
D. Pintaux Injector
E. All of the above

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

1 _____

Information Sheet-3 Documenting results with evidence and supporting information

3.1. Report writing port writing

3.1.1. Introduction

As technicians you may be called on to produce a report for a customer. If you are involved in research of some kind, it is important to be able to present results in a professional way. The following sections describe the main headings that a report will often need to contain together with an example report based on the performance testing of a vehicle alternator. Laying out results in a standard format is the best way to ensure all the important and required aspects of the test have been covered. Keep in mind that the report should convey clearly to another person what has been done. Further, a 'qualif ed' person should be able to extract enough information to be able to repeat the test – and check your f ndings. Use clear simple language remembering that in some cases the intended audience may not be as technically competent as you are.

3.1.2. Main headings of a report

The following suggestions for the headings of a professional report will cover most requirements but can, of course, be added to or subtracted from if necessary. After each heading, I have included brief notes on what should be included.

a. Contents If the report is more than about f ve pages, a list of contents with page numbers will help the reader f nd his or her way through it.

b. Introduction Explain the purpose of what has been done and set the general scene.

c. Test criteria Def ne the limits within which the test was carried out. For example, temperature range or speed settings.

d. Facilities/Resources State or describe what equipment was used. For example: 'A "Revitup" engine dynamometer, model number C3PO was used for the consumption test'.

e. Test procedures Explain here exactly what was done to gain the results. In this part of the report, it is very important not to leave out any details.

f. Measured results Present the results in a way that is easy to interpret. A simple table of f gures may be appropriate. If the trend of the results or a comparison is important, a graph may be better. Pictures of results or oscilloscope waveforms may be needed. If necessary a very complex table of results from which you draw out a few key f gures

could be presented as an appendix. You should also note the accuracy of any f gures presented (0.5% for example).

g. Analysis of results This is the part where you should make comment on the results obtained. For example, if, say, a fuel consumption test was carried out on two vehicles, a graph comparing one result to the other may be appropriate. Comments should be added if necessary, such as any anomaly that could have affected the results (change of wind direction for example).

h. Conclusions/Comments/Observations

Note here any further tests that may be necessary. Conclude that device X does perform better than device Y – if it did. If appropriate, add observations such as how device Y performed better under the set conditions, but under other circumstances the results could have been different. Comment on the method used if necessary.

i. Forecast If necessary comment on how the 'item' tested will continue to perform based on the existing data.

j. Appendices Detailed pages of results that would 'clog up' the main report or background material such as leaf ets relating to the test equipment.

3.1.3. Example report

An example report is presented here relating to a simple alternator test where its actual output is to be compared to the rated output. Minimal details are included so as just to illustrate the main points.

Introduction A 'Rotate' 12V alternator was tested under different temperature conditions to check its maximum output. The manufacturer's specifications stated that the alternator, when hot, should produce 95A at 6000rpm. Test criteria Start at room temperature. Run alternator at 3000rpm, 30A output for 10minutes. Run alternator at 6000rpm, maximum output. Check reading every 30seconds for 10minutes. Run alternator at 6000rpm, maximum output for a further 20minutes to ensure output reading is stable.

Facilities/Resources A 'Krypton' test bench model R2D2 was used to drive the alternator. The test bench re counter was used and a 'Flake' digital meter fitted with a 200A shunt was used to measure the output. A variable resistance load was employed.

Test procedures The alternator was run for 10 minutes at 3000rpm and the load adjusted to cause an output of 30A. This was to ensure it was at a nominal operating temperature. The normal fan was kept in place during the test. Speed was then increased to 6000rpm

and the load adjusted to achieve the maximum possible output. The load was further adjusted as required to keep the maximum possible output in case the load resistance changed due to temperature. Measurements were taken every 30seconds for a period of 10minutes.

Measured results Speed held constant at 6000 (200) rpm Room temperature (18°C). To ensure the alternator output had stabilized it was kept running for a further 20minutes at full output. It continued to hold at 96A.

Self-Check 3	Written Test

Instruction: - chose and write the letter of the correct answer on the space provided or on the separate answer sheet (2 pts)

1. Which one is not the parts of report?

A. Analysis of results
B. Conclusions/
C. Forecast
D. All of the above

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

1 _____

4.1. Forward report to appropriate persons

Maintenance Records Perkins recommends the retention of accurate maintenance records. Accurate maintenance records can be used for the following purposes:

• Determine operating costs.

• Establish maintenance schedules for other engines that are operated in the same environment.

• Show compliance with the required maintenance practices and maintenance intervals.

Maintenance records can be used for various other business decisions that are related to engine maintenance. Maintenance records are a key element of a maintenance program that is correctly managed. Accurate maintenance records can help your Perkins dealer to fine-tune the recommended maintenance intervals in order to meet the specific operating situation. This should result in a lower engine operating cost.

Records should be kept for the following items:

Fuel Consumption – A record of fuel consumption is essential in order to determine when the load sensitive components should be inspected or repaired. Fuel consumption also determines overhaul intervals.

Service Hours– A record of service hours is essential to determine when the speed sensitive components should be inspected or repaired.

Documents – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty: Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owners repair costs
- Owners receipts
- Maintenance log

Information for the following items may be needed to order parts. Locate the information for your engine. Record the information in the appropriate space. Make a copy of this list for a record. Keep the information for future reference.

Record for Reference

Engine Model_____

Engine Serial Number_____

Engine RPM_____

Primary Fuel Filter_____

Secondary Fuel Filter Element_____

Lubrication Oil Filter Element_____

Total Lubrication System Capacity_____

Total Cooling System Capacity_____

Air Cleaner Element_____

Maintenance Log

Table 1 Maintenance Log

Engine Model		Customer Identifier		
Serial Number		Arrangement Number		
Service Hours	Quantity Of Fuel	Service Item	Date	Authorization

Self-Check 4	Written Test

Instruction: - write true if the statement is correct or write false if the statement is incorrect and write the answer on the space provided or on the separate answer sheet (2pts)

1, A record of service hours is essential to determine when the speed sensitive components should be inspected or repaired.

2, Accurate maintenance records can be Determine operating costs.

Answer Sheet

Score = _____

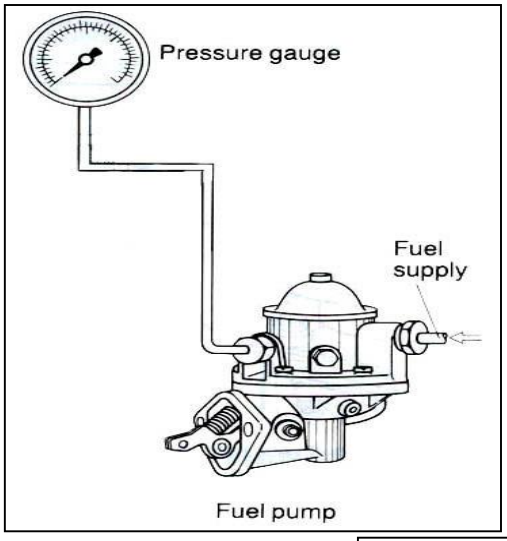
Rating: _____

Name: _____ Date: _____

1 _____ 2. _____

Mechanical Fuel Pump Test -

WORKSHEET 1



PROBLEM: The vehicle has a problem to reach full power / final speed. Engine mechanical and electrical systems have been checked. The carburetor including its float system, acceleration system and power system has been checked and found to be good as well.

Question1: In which other system / component part can be a possible reason for such a fault?

Question2: What should be the next test to be performed?

Engine manufacturer: ……
Engine type & size: ……. ……
Pressure specification: ……..

WORK ORDER:

1) Bring the engine to operation temperature.

2) Disconnect the fuel hose from the fuel pump outlet and fit a pressure gage instead.

3) Run the engine at fast idle.

(How can the engine still run though you disconnected it from fuel supply? ……)

4) Observe the pressure that is indicated at the gage. OBSERVATION: …...

(How is this pressure called? ……)

5) Your statement about the pressure magnitude: it is ☐ good ☐ poor

6) Stop the engine and observe the pressure (does it drop?).

OBSERVATION: ……..

8) What, if the pressure

a) drops? ……..…….

……..……..……..…….

or

b) remains constant? ……..……..

……..…….

9) CONCLUSION:

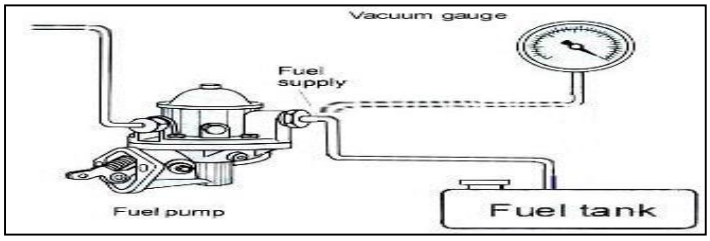
……

……

……..

Operation Sheet -2 Mechanical Fuel Pump Test-2

Fuel Pump Test-WORK SHEET 2



PROBLEM:

After the pressure test at the fuel pump (WS1), with the result of low pressure and pressure drop, the beginner technician asks the master:

"How do I know weather the pump itself (inlet/outlet valves) or the fuel supply line has a problem?"

QUESTION: Which test is suitable to identify the exact leakage point?

WORK ORDER:

1. Disconnect the feed hose from the fuel pump and fit the vacuum tester at the inlet of the fuel pump instead.
2. Run the engine, and adjust to the correct fast idle speed (not more than 2500 r.p.m.), till maximum vacuum value is shown on the vacuum tester.

How can the engine still run after you disconnected it from the fuel supply?

……

- How do you call this indicated vacuum
- How much is your reading (unit!)……. (your observation!)

3. Stop the engine and observe the vacuum tester reading for about 30 seconds.

Your observation: ……

4. What if the vacuum

Drops? ……or

Remains constant?

……

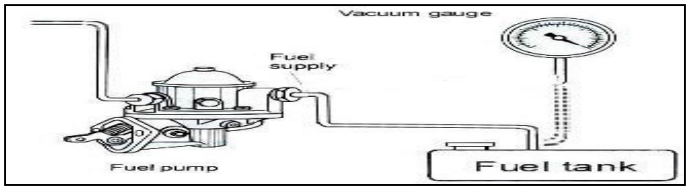
CONCLUSION:

……

……..

Operation Sheet-3 Mechanical Fuel Pump Test-3

Fuel Pump Test-WORK SHEET 3



PROBLEM: After the pressure test (WS1) and the suction test (WS2) at the fuel pump, with the result of low pressure / pressure drop at the outlet side, but no vacuum drop at the pump inlet side, the beginner technician asks the master:

"Now, how do I locate the problem?"

QUESTION: Which test is suitable to identify the exact leakage point?

WORK ORDER:

1. Get the float chamber refilled with fuel.
2. Disconnect the feed hose from the fuel tank (outlet) and fit the vacuum tester to the hose.
3. Run the engine, and adjust to the correct fast idle speed (not more than 2500 r.p.m.), till maximum vacuum value is shown on the vacuum tester.

How much is your reading? …… (your observation!)

4. Stop the engine and observe the vacuum tester reading for about 30 seconds.

Your observation: ……

5. What if the vacuum

Drops? ……

……or

Remains constant?

……

CONCLUSION:

……

• Read the pressure gauge just as the pressure begins to drop

Note: The nozzle is operating properly if you can hear a swishing sound. The opening pressure is 105-125 kg/cm2. If the opening pressure is not as specified, adjust the pressure by tightening or loosening the pressure spring using a screwdriver.

Perform a leakage test

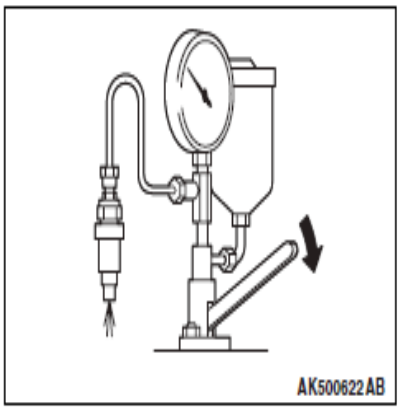
• Check that there is no dripping fuel from the injection hole or around the retaining nut. If the nozzle drips within ten seconds, clean, overhaul or replace the nozzle assembly.

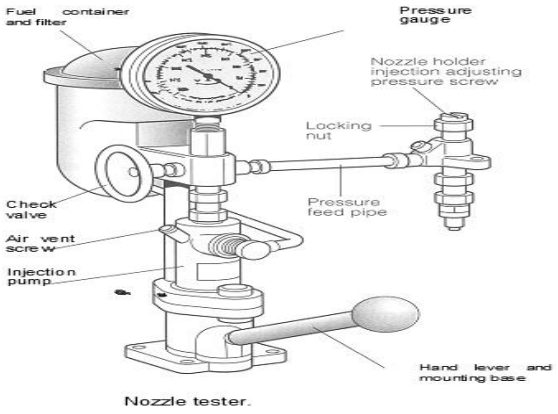
Perform a spray pattern test

• Check the spray pattern while the nozzle is shuddering. If the spray pattern is not correct (refer to figure below or the repair manual) the nozzle must be cleaned or replaced.

INJECTION NOZZLE CHECK AND ADJUSTMENT (Mitsubishi 4D5)

CAUTION! Never touch the injection spray that is injected from the nozzle.





Nozzle tester.

FUEL INJECTION INITIAL PRESSURE CHECK

1. Install the injection nozzle to a nozzle tester.
2. Move the lever of the nozzle tester 2 −3 times to inject fuel and to bleed the air.
3. Gently press down the lever of the nozzle tester, and take a reading of the indication value on the pressure gauge at the point where the needle slowly rises and then suddenly drops.

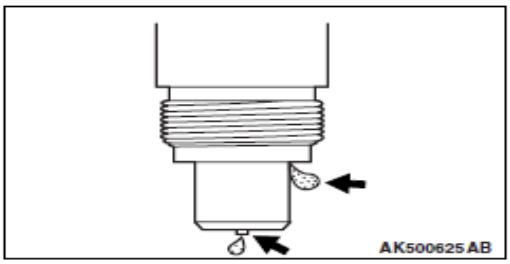
Standard value (Fuel injection initial pressure): 14,710 − 15,490 kPa

4. If the fuel injection initial pressure is outside the standard value, dis-assembly the Nozzle holder to clean it, and the change the thickness of the shim to adjust the fuel injection initial pressure.

INJECTION SPRAY CONDITION CHECK

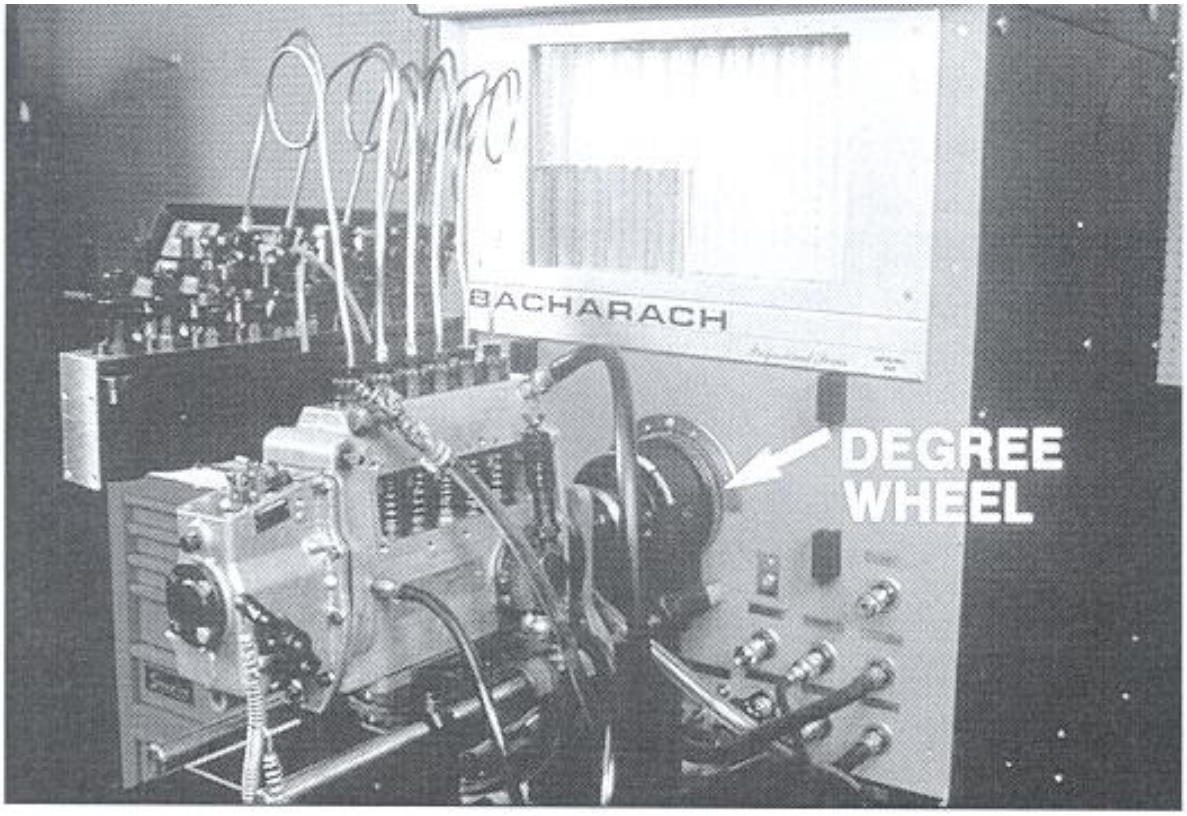
1. Move the lever of the nozzle tester rapidly (4 −6 times per second) to eject the Fuel continuously. Check to be sure that the injection spray comes out evenly in a cone shape
    i. Injection
    ii. Bias
    iii. Intermittent fuel injection
2. Check to be sure that no fuel drips after injection is completed.
3. If there are any drips, disassemble the nozzle, clean it and reinspect, or replace the nozzle.

NOZZLE FUEL-TIGHT CHECK



- Gently raise the lever of the nozzle tester until the pressure inside the nozzle (value displayed on pressure gauge) becomes 12,750 −13,730 kPa, and after holding this pressure for approximately 10 seconds, check to be sure that there are no fuel leaks from the nozzle.
- If there are any leaks, disassemble the injection nozzle, clean it and re-inspect, or replace the nozzle.

1. Connect the necessary high-pressure fuel lines on the test stand to the inlet fuel gallery of the injection pump,



2. Install a dial gauge on the number 1. pumping plunger so that when the pump camshaft is rotated the gauge will register the lift distance.

Zero the dial gauge with the pump camshaft lobe for the number 1 element at BDC

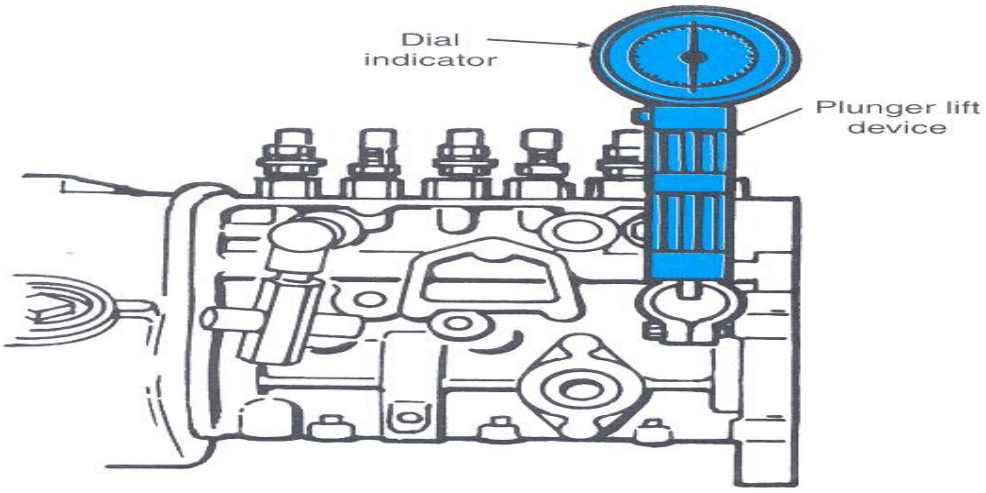


Figure 20-63. *Dial gauge in position on the pump's output to the number 1 cylinder. (Navistar International Transportation Corp.)*

3. Turn on the test stand fuel pump and allow calibration fluid to flow from the top of the number 1 delivery valve holder into a suitable container.

4.Slowly rotate the injection pump camshaft in its normal direction or rotation until the flow of fuel from the test stand tube cuts off to a series of drops. As in spill timing discussed earlier, this indicates that port closure has occurred.

5. Check the measurement on the dial indicator against lift specifications.

If it is not within the allowed tolerance, adjust the plunger lift.

This is done in a number of ways, depending on the exact injection pump model.

Some use shims below the spring seat and tappet, Figure

In others, the tappet lock nut is loosened and an adjust screw is rotated to obtain the desired lift

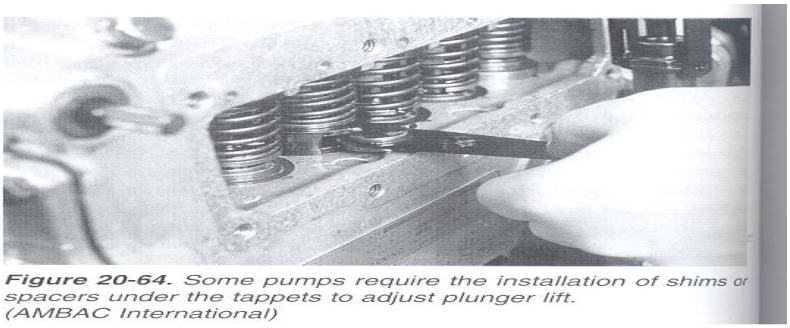


Figure 20-64. *Some pumps require the installation of shims or spacers under the tappets to adjust plunger lift. (AMBAC International)*

6. Once lift-to-port closure is set for cylinder number 1 loosen the test stand drive degree wheel and manual rotate it to the 0° setting.

7. Connect the fuel supply lines from the test stand to the pumping element for the next cylinder in the engine' firing order.

Activate fuel flow and rotate the camshaft by turning the test stand drive degree wheel.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Task 1: test injector pressure

Task 2- Perform injector a leakage test

Task 3- Mechanical Fuel Pump

LG #29	LO #3 Overhauling diesel/gasoline fuel injection system and components

Instruction sheet

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

- Accessing and interpreting Information from manufacturer specifications
- Carrying out overhaul of diesel/gasoline fuel injection system components
- Completing diesel/gasoline fuel injection system component overhaul without causing damage

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

- Access and interpret Information from manufacturer specifications
- Carrying out overhaul of diesel/gasoline fuel injection system components
- Complete diesel/gasoline fuel injection system component overhaul without causing damage

Learning Instructions:

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

1.1. Access and interpret Information

1.1.1. PRECAUTIONS

A. Before working on the fuel system, disconnect the cable from the negative battery terminal.
B. When working on the fuel system, keep away from possible fire hazards and do not smoke.
C. Keep gasoline off rubber or leather parts.
D. Work on only one component group at a time to avoid confusion between similar looking parts.
E. Keep work area clean to avoid contamination of the carburetor and components.
F. Be careful not to mix up or lose clips or springs.
G. Always use new gaskets when replacing the fuel tank or component parts.
H. When re-installing, be sure to include the rubber protectors on the upper surfaces of the fuel tank and tank band.
I. Apply the proper torque to all tightening parts.

1.2. BLACK SMOKE

Black exhaust smoke is caused by incomplete combustion because of a lack of air or a fault in the injection system that could cause an excessive amount of fuel in the cylinders. Items that should be checked include the following:

- Fuel specific gravity (API gravity)
- Injector balance test to locate faulty injectors using a scan tool
- Proper operation of the engine coolant temperature (ECT) sensor
- Proper operation of the fuel rail pressure (FRP) sensor
- Restrictions in the intake or turbocharger
- Engine oil usage

1.3. WHITE SMOKE

White exhaust smoke occurs most often during cold engine starts because the smoke is usually condensed fuel droplets. White exhaust smoke is also an indication of cylinder misfire on a warm engine. The most common causes of white exhaust smoke include:

- Inoperative glow plugs

- Low engine compression
- Incorrect injector spray pattern
- Coolant leak into the combustion chamber

1.4. GRAY OR BLUE SMOKE

Blue exhaust smoke is usually due to oil consumption caused by worn piston rings, scored cylinder walls, or defective valve stem seals. Gray or blue smoke can also be caused by a defective injector(s) or defective injector O-rings.

1.5. Injection Pump Service

- Most service is done by specialty shops with special tools and test stands
- External gasket, seal, and solenoid repairs may be made in a general shop

Self-Check 1	Written Test

Instruction: - chose and write the letter of the correct answer on the space provided or on the separate answer sheet (2 pts)

1, The most common causes of white exhaust smoke include?

A. Low engine compression
B. Incorrect injector spray pattern
C. Coolant leak into the combustion chamber.
D. All of the above

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

1 _____

2.1 Diesel Fuel System Components

- Tank and Cap
- Supply Pump: - to transfer fuel from the supply tank through the filters and lines to the injection pump. Supply pumps can be either external or internal to the injection pump.
- Fuel Filters Diesel fuel filters must be capable of trapping extremely small contaminants.
- Water Separators: - trapping and holding water that may be mixed in with the fuel.
- Injection Pump; - pumps fuel under high pressure through the fuel lines to the fuel injectors.
- Pressure and return Line
- Gauges
- Injection nozzle to deliver a precise amount of atomized and pressurized fuel into each cylinder.

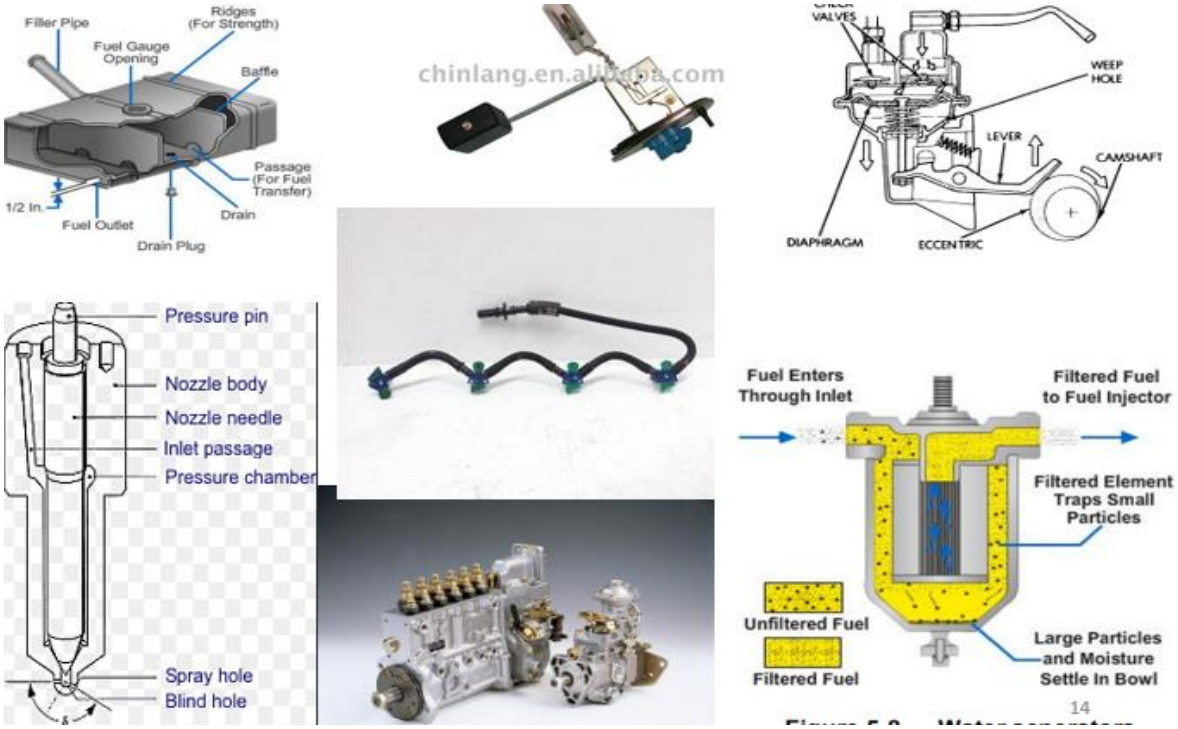


Figure 20 diesel fuel system component

Table 2 comparison table

	in line type	distributer
weight	heavier and lower rpm	lighter and high rpm
number of plunger	several (same as number of cylinder)	single
Governor	combined (pneumatically and mechanical) or mechanical	mechanical
Timer	separated (controlled by centrifugal force)	built in (controlled by fuel pressure)
Fuel cut off	a device to drive control rack is provided (EDIC)	use solenoid valve
lubrication	self-lubricated by fuel and engine oil	self-lubricated by fuel only
Feed pump	fitted to side of injection pump	built in

2.2 Types of conventional injection pump

1. inline injection pump

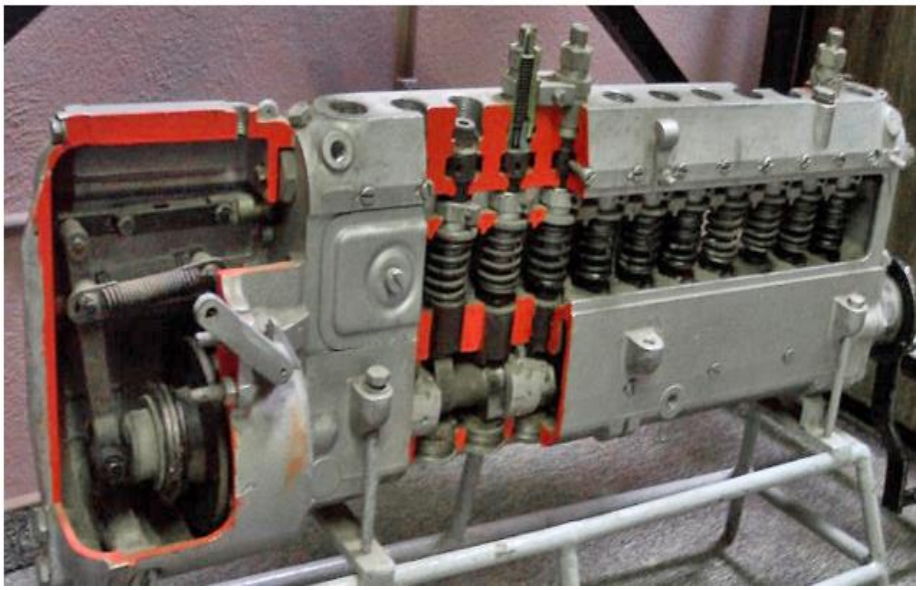


Figure 21 inline injection pump

2. Distributer type

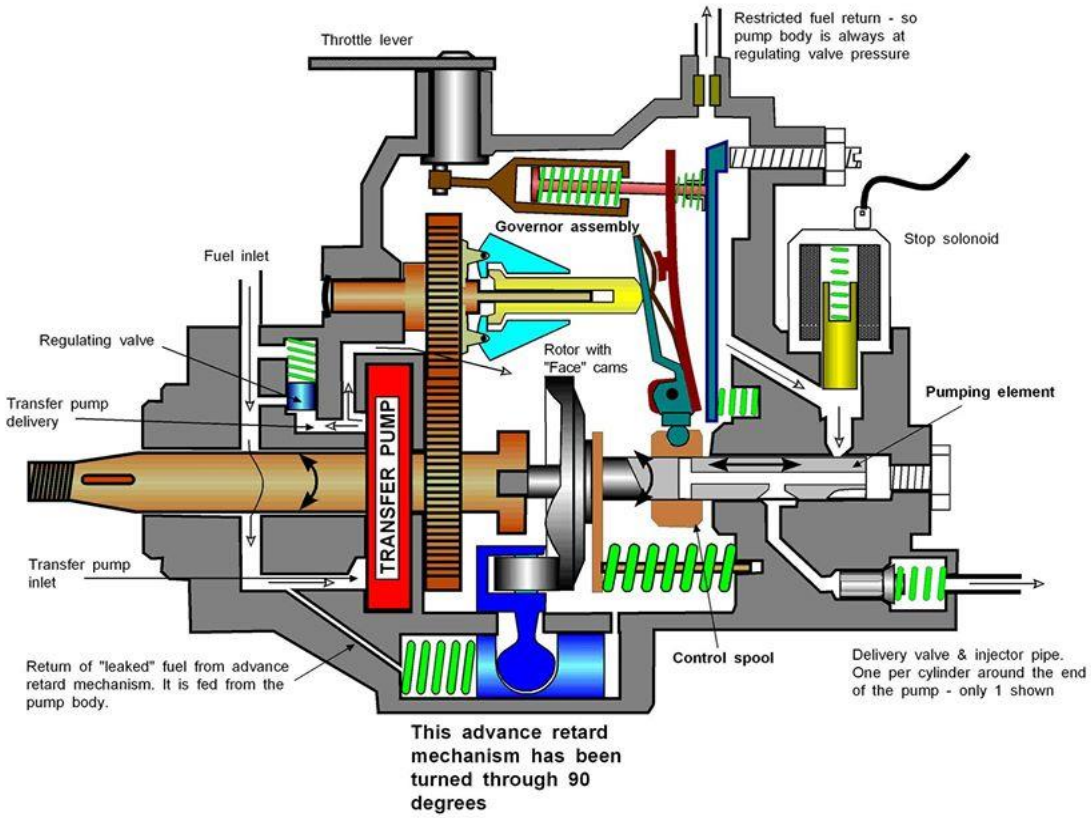


Figure 22 Distributer type injection pump

2.3 Problems with Petrol

Petrol has two problems when burned in car engines. The first problem has to do with smog and ozone in big cities. The second problem has to do with carbon and greenhouse petrol's.

When cars burn petrol, they would ideally burn it perfectly and create nothing but carbon dioxide and water in their exhaust. Unfortunately, the internal combustion engine is not perfect. In the process of burning the petrol, it also produces:

• Carbon monoxide, a poisonous petrol

• Nitrogen oxides, the main source of urban smog

• Unburned hydrocarbons, the main source of urban ozone

Catalytic converters eliminate much of this pollution, but they aren't perfect either. Air pollution from cars and power plants is a real problem in big cities.

Carbon is also a problem. When it burns, it turns into lots of carbon dioxide petrol. Petrol is mostly carbon by weight, so a litter of petrol might release 0.6 kg of carbon into the

atmosphere. If it were solid carbon, it would be extremely noticeable. The carbon dioxide coming out of every car's tailpipe is a greenhouse petrol. The ultimate effects are unknown, but it is a strong possibility that, eventually, there will be dramatic climate changes that affect everyone on the planet (for example, sea levels may rise, flooding or destroying coastal cities). For this reason, there are growing efforts to replace petrol.

2.4 GENERAL TROUBLESHOOTING

When troubleshooting a diesel engine, keep in mind that problems associated with one make and type of engine (two-stroke versus four-stroke) may not occur exactly in the same way as in another. Specifically, particular features of one four-stroke-cycle engine may not appear on another due to the type of fuel system used and optional features on that engine.

Follow the basic troubleshooting steps listed below before rolling up your sleeves and trying to pinpoint a problem area.

1. Obtain as much information from the operator as possible concerning the complaint.
2. Analyze the problem in detail first, beginning with the smallest and simplest things.
3. Relate the problem symptoms to the basic engine systems and components.
4. Consider any recent maintenance or repair job that might tie into the problem.
5. Always double-check and think about the problem before disassembling anything.
6. Solve the problem by checking the easiest and simplest things first.
7. If possible, use the special tools and diagnostic equipment at your disposal to verify a complaint and pinpoint the general area.
8. Determine the cause(s) of the problem and carry out the repair.
9. Operate the engine and road test the vehicle to confirm that the problem is corrected.

Complaint	Possible Cause	Check or Correction
1. Engine cranks normally but will not start	**a.** incorrect or dirty fuel **b.** No fuel to nozzles or injection pump. **c.** Plugged fuel-return line **d.** Pump timing off **e.** Inoperative glow plugs, incorrect starting procedure, or internal engine problems	Flush system use correct fuel Check for fuel to nozzles Check return line, clean Retime
2. Engine starts but stalls on idle	**a.** Fuel low in tank **b.** Incorrect fuel or dirty fuel **c.** Limited fuel to nozzles or injection pump. **d.** Restricted fuel-return line **e.** Idle incorrectly set **f.** Pump timing off **g.** Injection-pump trouble **h.** Internal engine problem	Fill tank Flush system—use correct fuel Check for fuel to nozzles and to pump Check return line, clean Reset idle Retime Install new pump
3. Rough idle, no abnormal noise or smoke	**a.** Low idle incorrect **b.** Injection line leaks **c.** Restricted fuel-return line **d.** Nozzle trouble **e.** Fuel-supply-pump problem **f.** Uneven fuel distribution to nozzles **g.** Incorrect or dirty fuel	Adjust Fix leaks Clear Check, repair or replace Check, replace if necessary Selectively replace nozzles until condition clears up Flush system use correct fuel
4. Rough idle with abnormal noise and smoke	a. Injection-pump timing off b. Nozzle trouble	Re time Check cylinders in sequence to find defective nozzle
5. Idle okay but misfires as throttle opens	a. Plugged fuel filter b. Injection-pump timing off c. Incorrect or dirty fuel	Replace filter Re time Flush system—use correct fuel

6. Loss of power	a. Incorrect or dirty fuel b. Restricted fuel-return line c. Plugged fuel-tank vent d. Restricted fuel supply e. Plugged fuel filter f. Plugged nozzles g. Internal engine problems, loss of compression, compression leaks	Flush system—use correct fuel Clear Check fuel lines, fuel-supply pump, injection pump Replace filter Selectively test nozzles, replace as necessary
7. Noise—“rap” from one or more cylinders	a. Air in fuel system b. Gasoline in fuel system c. Air in high-pressure line d. Nozzle sticking open or with low operating pressure e. Engine problems	Check for cause and correct Replace fuel Bleed system Replace defective nozzle
8. Combustion noise with excessive black smoke	a. Timing off b. Injection-pump trouble c. Nozzle sticking open d. Internal engine problems	Reset Replace pump Clean or replace

2.5 Monitor the color of the smoke

Types of smoke	Causes
White Smoke	• Low cylinder compression from worn rings • Scored piston or liner • Valve seating problems • Water leaking into the combustion chamber • Faulty injectors • Use of a low cetane diesel fuel
Black or Gray Smoke	• Improper grade of diesel fuel • Air starvation • High exhaust back pressure • Incorrect fuel injection timing • Faulty nozzles or injectors

	• Incorrect valve adjustment clearances • Faulty injection pump • Faulty automatic timing advance unit
Blue smoke	• Worn valve guides • Worn piston rings • Worn cylinder walls • Scored pistons or cylinder walls • Broken ring • Turbocharger seal leakage • Glazed cylinder liner walls due to use of the wrong type of oil

2.6 On vehicle Inspection, test, service and calibration

- Quick Injector Misfire Check or dead cylinder test
- Inspection of fuel lines, fittings and hoses
- Fuel filter replacement and discharge water from the system
- Bleeding air from fuel system
- Fuel system flush
- Injection-pump timing adjustment
- Cleaning Dirt in fuel system components

Self-Check 2	Written Test

Instruction: - chose and write the letter of the correct answer on the space provided or on the separate answer sheet (2 pts)

1.Which one is not the Couse of the blue smoke?

A. Worn valve guides

B. Worn piston rings

C. Worn cylinder walls

D. Faulty injection pump

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

1 _____

3.1. Taking Care of a Petrol Fuel System

The basic servicing care of a petrol fuel system involves two (2) “F’s”; filters and fuel. It is important to replace the fuel filter on a carbureted engine periodically so that they don’t block up with debris and stop fuel flowing. Sintered metallic filters mounted right at the carburetor’s fuel inlet are sometime prone to this. Interestingly most carbureted engines don’t have fuel filters between the fuel tank and the fuel pump.

WARNING

When replacing a fuel filter on:

• A carbureted engine, some minor fuel spillage can occur when the fuel line is disconnected to change the filter.

• On a fuel injected engine it operates at very high fuel pressures. Opening or disconnecting any fuel system component without fully depressurizing the system is

extremely dangerous. Many fuel filters require a special tool to disconnect fuel lines.

3.2. Garages - Fuel Safety

What should I do when receiving fuel from the delivery truck?

- Do not allow smoking, flames, sparks or other sources of ignition near the fuel storage and handling areas. Gas vapors are heavier than air and will drift downward from the source. It is the vapor, not the liquid, which burns.
- Follow safety recommendations of your fuel supplier during fuel delivery. Report fuel spills according to environmental and health and safety regulations.
- Use absorbent materials to clean up and prevent the spill from spreading.
- Position the fuel delivery truck so that it does not interfere with the movement of other vehicles.
- Make sure that fuels are delivered into the correct tank.
- Check the levels in the tank to determine quantity needed before receiving commercial delivery.

- Check the area around the vents of the receiving tanks for possible ignition sources.
- Observe the vents during delivery for proper operation. Stop delivery if fuel is being ejected.
- Have the driver stay near the truck flow valve while the fuel is flowing into the storage tank in case of the need for emergency shut-off.
- Reinstall the fill and gauge caps.
- Mark gauge and fill caps clearly to indicate the fuel type.
- Open caps only during filling and gauging to minimize the release of fuel vapors.
- If a fire starts, do not remove the hoses or nozzles. Leave the area immediately. Alert others to do the same. Call the fire department.

3.3. What are some safety tips for handling fuel?

- Only store the minimum amount of gasoline needed.
- Use only approved portable containers (e.g., CSA or ULC approved).
- Store containers at room temperature, away from sources of heat or ignition (e.g., sun, furnace, hot water tank, portable heaters, sparks, flames, etc.), and in a well ventilated area.
- Remember, gasoline vapors are flammable, are heavier than air, and can travel long distances to an ignition source.
- Never siphon gasoline by mouth. It is harmful and may cause death if swallowed. If ingested, do not induce vomiting. Get medical help immediately.
- Do not smoke.
- Avoid prolonged or repeated skin contact with fuel. Wash skin thoroughly with soap and water in case of contact.
- Avoid breathing in vapor's or mists.
- Remove any clothing that is wet with fuel. Allow fuel to evaporate completely outdoors before washing. Thoroughly clean clothing before reuse.
- Never use gasoline as a cleaning agent.

3.4. What should I do when fueling vehicles?

- Refer to the vehicles operating manual for special instructions.
- Identify and know how to operate emergency fuel cut offs.

- Know the location of, and how to operate fire extinguishers.
- Always shut off an engine while fueling.
- Remove twists and small loops in the fuel delivery hose. These kinks can cause the hose to fail or catch on bumpers as vehicles move around the pump islands.
- Insert delivery hose nozzle firmly into the fill pipe of the vehicle. Maintain contact with the tank until the delivery is complete to reduce possibility of static electricity sparking.
- Avoid spills by not over-filling the tank.
- Reinstall the cap on the fill pipe when delivery is complete. Hang the hose in place on the pump.
- Fill motorcycles slowly to prevent fuel from spilling and making contact with the hot engine.
- Do not use the gas cap or other objects to hold the fuel delivery nozzle open.

3.5. How do I fill a portable gas container?

- Turn off all sources of ignition (engine, lawn mower, etc.).
- Use only approved portable containers (e.g., CSA or ULC approved).
- Place the container on the ground.
- Keep the fuel nozzle in contact with the container to avoid static electricity.
- Avoid breathing vapor's while filling.
- Fill the container slowly.
- Do not over-fill a container. Leave 5% extra space to allow for expansion.

3.6. Before work is done on a fuel tank, what should I do?

- Clean and test tank to ensure that it is free of any flammable fuel or vapours before doing hot work on a tank. Verify with air testing. When possible, replace the fuel tank rather than repair it. Repair tanks only in specialized shops by qualified personnel.
- Disconnect the battery and remove or turn off ignition sources before draining the tank.
- Drain tanks only in well-ventilated areas, preferably outdoors.
- Drain the fuel into containers that are approved for use with flammable liquids.
- Do not drain gasoline tanks over or near inspection pits.
- Use approved siphoning equipment to remove fuel. Do not use a hose.

- If the fuel tank is removed from the vehicle or if welding will be carried out near the fuel lines, ensure that the lines are drained and the vapours are purged from the lines before the welding activities are started.

3.7. If the vehicle tank leaks:

- Keep vehicle outdoors.
- Ground and bond vehicle to a proper siphon tank.
- Pump out remaining fuel into approved container.

Self-Check 3	Written Test

Instruction: - write true if the statement is correct or write false if the statement is incorrect and write the answer on the space provided or on the separate answer sheet (2 pts)

1. Before work is done on a fuel tank Do not drain gasoline tanks over or near inspection pits?
2. when fueling vehicles Identify and know how to operate emergency fuel cut offs

Answer Sheet

Score = _____
Rating: _____

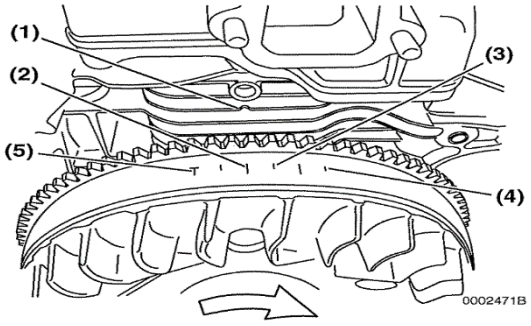
Name: _____ Date: _____

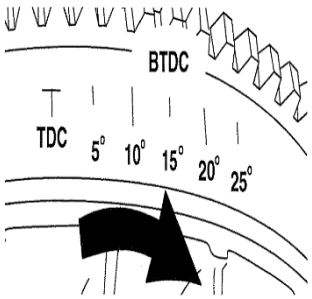
1 _____ 2 _____

Operation Sheet-1 injection pump removal

Pump Removal

- Set engine No. 1 piston at TDC
- Observe pump timing marks





1 TDC mark

2 measured timing mark / timing retarder

3 target timing mark (15°)

4 measured timing mark / advance timing mark

5 TDC Top Dead Center

- Disconnect battery
- Remove injection lines, linkages, wires, and fasteners
- Cap all lines
- Remove pump
  - Note the parts that must be disconnected before removal

Pump Installation

- Align timing marks as you install pump
- Torque fasteners and lines to specifications
- Reconnect battery
- Air bleeding may be necessary
- The pump will be timed using various methods

Pump Adjustments

- Injection pump timing
- Cable/linkage adjustment
- Cold idle speed

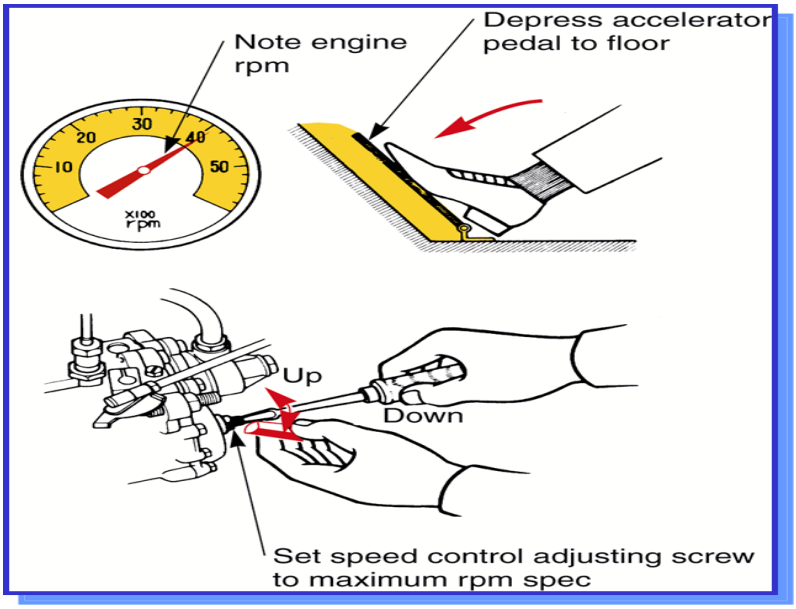
- Maximum speed

Injection Pump Timing

- Rotate the pump against the direction of rotation to advance timing; rotate the pump with the direction of rotation to retard timing

Maximum Speed

- Limits highest attainable engine rpm
- Position tachometer so that it can be read from driver's seat
- With the transmission in neutral or park and the brakes on, slowly press the accelerator to the floor
- If maximum speed is not within specifications, turn adjusting screw on the injection pump



Operation Sheet-2 Service Diesel Injector Nozzle

Servicing Procedure

1. Remove the fuel injectors from the engine. Cover the injectors with shop towel before loosening to avoid squirting highly pressurize fuel towards you.
2. Examine the appearance of the nozzle tips of each injector.
3. If the fuel injector is dirty, it must be cleaned in a container with highly volatile liquid such as gasoline or fuel injector cleaner.
4. Follow all safety precautions and operating instructions in the shop to avoid injury, damage and fire.
5. If the injector is clogged, disassemble it carefully without damaging the parts.

Fuel Injector Dis assembly (see figure below)

a) Clamp the injector by its nozzle holder in a suitable vise.
b) Remove the nozzle cap, nozzle cap nut, and gasket using an appropriate wrench
c) Remove the nozzle holder together with the nozzle body
d) Remove the nozzle needle pin from the nozzle body without touching the mating
e) surfaces with fingers
f) Remove the retaining nut
g) Use a flat screwdriver to loosen the spring cap, then remove the pressure spring
h) Remove the nozzle holder from the vise and take the pressure pin out.

6. If the injector is severely damaged and no replacement parts are available, replace it with a new one.
7. Clean the fuel lines connecting the injectors.
8. Clean the fuel return line.
9. Assemble the injectors

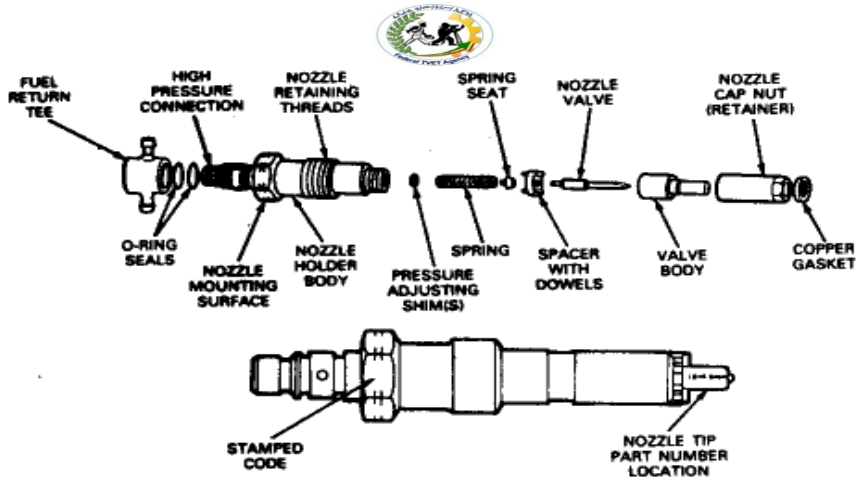


Figure 23 fuel injector disassembling

10. Perform Nozzle Testing using Injector Tester according to service specifications/manuals

Perform an injector pressure test

- Set the injector to the high-pressure pump
- Operate the pump and observe the pressure gauge
- Read the pressure gauge just as the pressure begins to drop

Note: The nozzle is operating properly if you can hear a swishing sound. The opening pressure is 105-125 kg/cm2. If the opening pressure is not as specified, adjust the pressure by tightening or loosening the pressure spring using a screwdriver.

Perform a leakage test

- While maintaining a pressure of 10-20 kg/cm2 lower than the opening pressure, check that there is no dripping fuel from the injection hole or around the retaining nut. If the nozzle drips within ten seconds, clean, overhaul or replace the nozzle assembly.

Perform a spray pattern test

- The injection nozzle shudders at certain pumping speed between 15-60 times

  (old nozzle) or 30-60 times (new nozzle) per minute.

- Check the spray pattern while the nozzle is shuddering. If the spray pattern is

  not correct (refer to figure below or the repair manual) the nozzle must be cleaned or replaced.

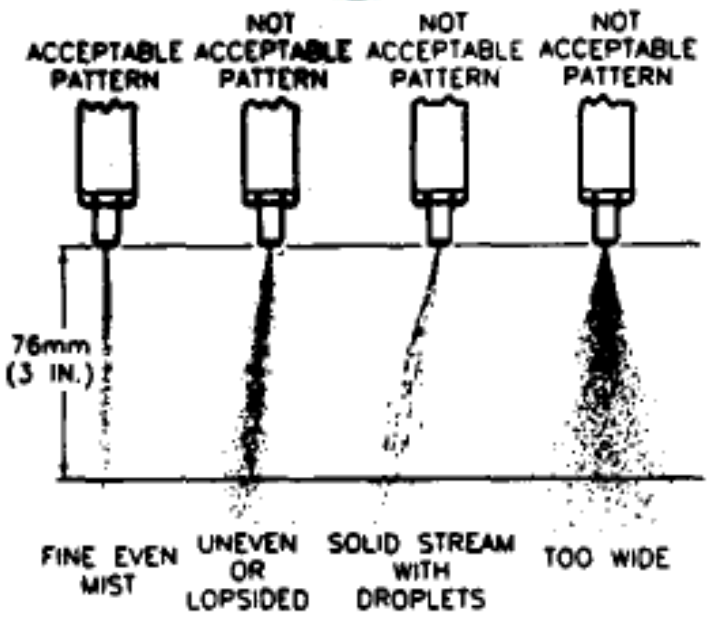


Figure 24 Spray Pattern

On-Vehicle Inspection

1 Remove Air Cleaner
2 Check Carburetor and Linkage
3 Check Float Level

Cold Engine

4. Check Automatic Choke
5. Check Choke Opener
6. Check Choke Breaker
7. Check AAP System
8. Check Outer Vent Control Valve Hot Engine
9. Check Automatic Choke
10. Check Choke Opener
11. Check AAP System
12. Check Acceleration Pump
13. Check Fuel Cut System
14. Install air Cleaner
15. Check and Adjust the Idle Speed
16. Check and Adjust Fast Idle Speed

Removal of Carburetor linkage

1. Remove Air Cleaner
2. Disconnect Throttle Cable for automatic Transmission
3. Disconnect Following Hoses from Carburetor
   (A) Emission Control Hoses
   (B) PCV Hose from The Flange
   (C) Fuel Hose
   (D) Wiring Connector
4. Disconnect Accelerator Linkage

REMOVE CARBURETOR

(a) Remove the carburetor mounting bolts and nuts.

(b) lift out the carburetor.

(c) Cover the inlet hole of the intake manifold with a cloth.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Task 1: Remove Carburetor without damage

Task 2- Remove Air Cleaner without damage

LG #30 LO #4- Prepare to carry out engine overhaul

Instruction sheet

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

- Making final inspection to ensure protective guards, safety features
- Making final inspection to ensure conformance
- Cleaning and making vehicle fuel system and/or components
- Processing Job card in accordance with workplace procedures

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

- Make final inspection to ensure protective guards, safety features
- Make final inspection to ensure conformance
- Clean and making vehicle fuel system and/or components
- Process Job card in accordance with workplace procedures

Learning Instructions:

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

1.1. Fuel Line Inspection

Use the following general guidelines when installing and routing new fuel lines:

- There should be no loops, sharp bends, or kinks (eccentricity) in the lines,
  - since they often add restriction and turbulence.
- Any line extending more than 5.08 cm below the bottom of the fuel tank must be enclosed in a protective housing.

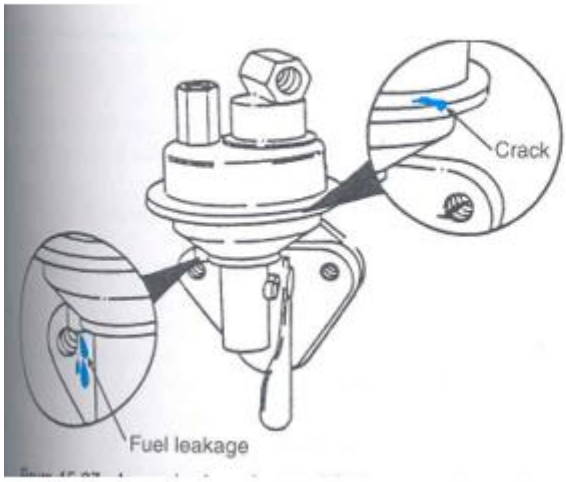
Secure fuel lines to the engine or chassis to prevent damage.

- Fuel lines should be as short as possible, but long enough to allow movement of any parts to which they are attached.
- Coat all pipe junctions and tapered threads with an approved sealant.
- Tighten the line connectors until snug (close-fitting), but avoid over tightening. Over tightening can strip the threads
- Drains and other bottom fittings should not extend more than 19.05 mm below the lowest part of the fuel tank or sump.
- When replacing a fuel line, the new line must match the size, shape, and length of the original line
- To prevent metal lines from bending, use only one hand with two wrenches for final tightening,
- Check that new lines and fittings are free of leaks. If air enters through a leak, it can result in a loss of prime in the fuel system.

1.2. Fuel Transfer Pumps

- Inspecting and Cleaning
  - Once the diaphragm transfer pump is removed from the fuel system,
    - visually inspect it for cracks or other damage.
    - Check the weep hole area for signs of fuel leakage,
    - Clean the pump in solvent, and blow it dry with compressed air.
    - Carefully examine the camshaft lever and the return spring for excessive wear.

- Inspecting **and Cleaning**



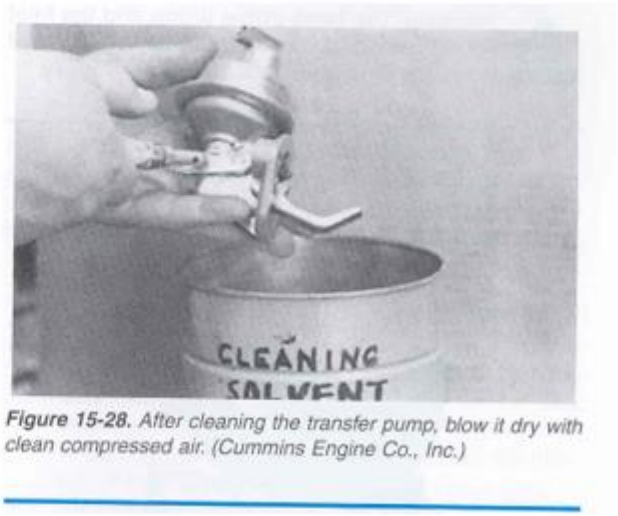


Figure 15-28. *After cleaning the transfer pump, blow it dry with clean compressed air. (Cummins Engine Co., Inc.)*

Self-Check 1	Written Test

Instruction: - chose and write the letter of the correct answer on the space provided or on the separate answer sheet (2 pts)

1 Final inspection is used to prevent ?

A. Assemblies process

B. Tight the loosen bolt

C. Clean final cleaning .

D. All of the above

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

1 _____

2.1 What parts need to get inspected:

The fuel filter needs to be inspected and replaced the most often out of all the parts in the fuel system. It should be replaced every 10,000-15,000 miles.

The hoses running fuel to components in the engine bay should be inspected regularly, preferably whenever the car is being professionally serviced.

Fuel injectors should be inspected annually, but if there are issues with fuel delivery they should definitely get checked out by a mechanic.

If fuel is leaking under the car, the hard fuel lines should be inspected.

The fuel pump will last around 100,000 miles, but if it begins surging fuel towards the engine or not delivering enough fuel, it needs to get inspected regardless of the mileage.

A fuel tank will last at least 10 years. To extend the life of a fuel tank, avoid water and excess moisture at all cost.

With regular inspections and maintenance, the fuel system will last for a long time and provide the vehicle with consistent performance. Emissions control and other systems rely on proper fuel delivery as well.

2.2 Four Types and Intervals for Inspections

Inspection Type	When Performed?	Inspection Level	What is Inspected?	Who Performs?
Pre-Service Inspection	Prior to placing vehicle in service	Detailed Visual Inspection	Thorough inspection of all high pressure components, including cylinders	A certified or qualified CNG Fuel System Inspector
Driver Pre- and Post-Trip Inspection	Before and after each trip in a CNG vehicle	Cursory Visual Inspection	All visible components and cylinder shields	Driver
General Visual Inspection	During any preventive maintenance/service	General Visual Inspection	All visible components, with special attention to cylinder shields	Trained Vehicle Technician
Detailed Visual Inspection	At manufacturer's specified intervals, or 3 years/36,000 miles (whichever comes first); after any fire or accident	Detailed Visual Inspection	Thorough inspection of all high-pressure components, including cylinders	A certified or qualified CNG Fuel System Inspector

Figure 25 four types of inspection

Self-Check 2	Written Test

Instruction: - write true if the statement is correct or write false if the statement is incorrect and write the answer on the space provided or on the separate answer sheet (2pts)

1. Fuel injectors should be inspected annually

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

1 _____

1.1. Fuel System Component Cleaning And Procedure Guide

1.1.1. Important Safety Precautions

warning gasoline is extremely flammable and its vapors are potentially explosive. work in a well-ventilated area away from sparks and open flames. always relieve the fuel system pressure using the original equipment manufacturer's recommended procedure before servicing fuel system components. failure to take these precautions can result in fire, damage to property and serious injury or death.

high-pressure fuel systems should be serviced by qualified technicians. leaking liquid fuel may ignite and fuel vapors may explode, both resulting in personal injury and i or property loss. read vehicle repair manual for safety precautions, and follow this guide for your protection.

IMPORTANT: Failure to clean the fuel tank and install a new strainer may allow contaminants to enter the pump and void warranty. Contamination is the leading cause of fuel pump failure.

The purpose for this guide is to provide instructions and procedures for cleaning and removing

contaminants from the fuel tank.

A new fuel pump can't restore quick starting, smooth idling or provide exhilarating performance to an engine with a dirty fuel tank. Many vehicles with drivability complaints respond well to a clean fuel tank, a new strainer (filter) and new fuel pump.

WORK CLOTHING Wear a long-sleeved shirt, long trousers, and safety shoes. Don't wear a ring

or watch that might draw an electric spark. If fuel spills on your clothing, change it right away.

EYE PROTECTION Wear safety goggles or safety glasses. If fuel splashes into eyes, flush with

water first, then go for emergency medical aid.

FUEL HOSE Never use standard low-pressure fuel hose in high-pressure fuel injection systems. Use high-pressure hose marked EFI/EFM, or equivalent.

Safety Precautions

- Keep a Class A/B/C fire extinguisher nearby.
- Don't smoke when servicing fuel systems.
- Ventilate service area; duct exhaust outside.
- Avoid open flames from matches, lighters, and torches in or near the service area.
- Use a shielded fluorescent droplight instead of an incandescent bulb; turn off soldering irons.
- Clean up fuel spills right away; dispose of fuel-soaked rags and absorbent properly.
- Relieve fuel pressure before opening the systems. Otherwise, high-pressure spray might cause a
- fire or other personal injury.
- Check for cracked fuel lines and leaky fittings before and after fuel-system service.
- Never use a finger to check fuel injector pattern or pressure. High-pressure fuel can penetrate
- unbroken skin, causing illness.
- Never energize fuel injector with fuel line connected except when following a service manual for procedures and precautions.
- Always dispose of surplus fuel responsibly.

1.1.2. KEEP EVERYTHING CLEAN!

Fuel contaminants like dirt, rust and scale are a primary cause of in-tank fuel pump failure, and they can cause the replacement pump to fail prematurely. For a successful installation, you must keep everything totally clean - beginning to end.

1. Clean accumulated road dirt from top of fuel tank, taking special care around the pump access area. (Cover fuel inlet tubes first.) Also clean tank filler pipe.

2. Inspect the fuel strainer for stains from rust, clogging from dirt, and slime from water. (Some fuels contain up to 10% alcohol, which attracts water that accumulates in the tank.) If contaminated, the tank must be drained before installing the new pump. If the interior is rusted, the tank must be cleaned and inside surface sealed, or it must be replaced.

3. Keep the replacement pump in its package until you're ready for it, and leave caps on inlet and outlet fittings while installing pump in hanger.

4. Place the replacement pump, or the pump to be reinstalled, on a clean worktable, or lineless shop towel. Electric fuel pumps are made to extremely close

tolerances, so are easily damaged by the smallest contaminants. Keep your hands clean.

5. Install new strainer. Make sure its retaining clamp fits snugly on the pump Inlet to prevent contaminated fuel from bypassing the strainer.

6. Protect filler neck and inlet/outlet openings from dirt when reinstalling fuel tank in vehicle. Stuff clean shop towels in tank openings and tape over fittings until ready to reconnect lines or hoses.

1.1.3. REMOVING THE FUEL TANK

1. First, release tank pressure by removing the filler cap. Then relieve fuel system pressure by removing the pump fuse and running the engine until it quits from fuel starvation. Crank engine briefly to confirm pressure relief.

NOTE: Some systems have two fuel pumps: low-pressure in-tank, and high-pressure inline. Be sure to disable both fuel pumps when this applies.

WARNING; Gasoline vapors are explosive! To reduce the possibility of sparking, disable the electrical system by disconnecting the negative (-) battery cable.

2. Clean accumulated road dirt from top of fuel tank, taking special care around the pump access

area (Cover fuel inlet tubes first.) Also clean tank filler pipe.

3. Drain fuel to lighten the tank and avoid spilling when removing the pump hanger assembly. Use only an approved container, preferably one that filters the fuel for reuse in the vehicle.

4. Remove the fasteners for the fuel tank filler neck, noting there're different sizes and locations, then raise vehicle on hoist. (If working without a hoist, use an approved floor jack to raise the vehicle and approved jack stands to support it.)

5. Support the tank with a transmission stand or floor jack. Note location of fuel outlet, fuel return and vapor lines. Remove the lines, using a clean shop towel to absorb draining fuel, and inspect them for cracking or chafing. When replacing high-pressure lines, use only "EFM/EFI" hoses or equivalent. Disconnect pump wiring harness.

6. Remove tank straps, and filler neck tube if necessary. Lower tank enough to access fuel pump hanger assembly or completely remove tank. If tank is rusted inside, or seriously damaged, it must be repaired or replaced before proceeding. Also replace hangers that show excessive rust, wear or damage.

7. Once the tank has been removed, drain the fuel completely from the tank. Use only an approved container, preferably one that filters the fuel for reuse in the vehicle. Remove the fuel pump hanger assembly to a designated work area. Swish the fuel tank around in a circular motion to settle any debris remaining in the tank. Turn tank over, then tap bottom to remove debris. After debris has been removed, turn tank on its bottom. Take a lineless shop towel and wipe the inside of the tank until it is clean.

1.1.4. REINSTALLING PUMP HANGER ASSEMBLY AND FUEL TANK

1. Replace the hanger assembly, making sure it's positioned exactly as before. Take care not to allow dirt or water to enter the tank, because contaminates will cause premature pump failure.

2. Install the new tank seal in the tank channel or the hanger lip. Fasten with screws tightened to the manufacturer specifications. Or, hand-tighten the lock ring and snug it down by tapping with a non-ferrous punch. Don't use gasket sealant!!!

3. To run-test the pump, position the tank so you can connect fuel lines and electrical wiring. Make sure the tank holds enough fuel to prevent the pump from running dry! Reattach the negative battery cable and switch the ignition on. You'll hear the pump operate for a few seconds, then shut off. If not, disconnect the battery again and review the installation from here on back to the beginning.

4. Everything checks out okay. Great! Install the filler neck, if necessary; secure the tank straps; remove the jack stands and lower the vehicle. Refill tank with fresh fuel, or the filtered clean fuel you drained from the tank.

Self-Check 3	Written Test

Instruction I: - chose and write the letter of the correct answer on the space provided or on the separate answer sheet (2 pts)

1. When working on a fuel system safety pre questions are

B. Keep a Class A/B/C fire extinguisher nearby.

C. Don't smoke when servicing fuel systems.

D. Ventilate service area; duct exhaust outside.

E. All of the above

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

1 _____

4.1. Process Job card

The job card is meant to ensure that the technician working on the vehicle, has a detailed 'patient' file which will help ensure that every job is completed professionally and every vehicle receives the technician's full attention and application.

The job card is also a great tool for your technicians to highlight additional repairs or maintenance items that they notice and which really need attention. This is where your job card works in conjunction with your cross selling lists, a subject to be covered as part of this series of business strategies.

Let's face it, technicians are only human, and they have lazy or bad days, and they might forget things. So the number one role of the job card is to prompt technicians to undertake every job to your workshop's high standard and to the customer's expectations.

To make this work, your job card must contain every item you would like your technicians to check and report on. The job card can be as detailed as you like.

4.1.1. The advantages of a good job card are:

- to reduce idle time by giving technicians the information and tools to be productive and efficient
- to provide clear, logical and suitable information to the technician and to the person costing the job
- to provide a very effective automatic link between the workshop and the front office
- to provide particulars of each job accurately
- to provide detailed information on the vehicle both at the time of repair and on future visits to the workshop.

4.2. **The job card should contain the following information:**

4.2.1. **Job number**

Larger workshops use job numbers to identify vehicles and to allow technicians to easily find jobs when required. These can sometimes also be customer numbers. It's important to only refer to job and customer numbers in-house and not directly with a customer. Always refer to a customer by name and their vehicle by make and model.

4.2.2. **Customer's name and full contact details**

Correct customer information is very important. Names must be spelt correctly and any titles clearly noted. Make sure the contact phone number is the one on which the customer will be available, and the correct mailing address so you can send them a thank you letter or service reminder. Most point of sale programs will print this out on your job card, but you should always ensure details are correct.

4.2.3. **Complete vehicle details**

This would include rego number, make and model, manufacture details including VIN number, manufacture date, engine code and number of cylinders. Such detail is vital when ordering parts. Kilometers travelled must be noted, particularly if related to warranty. Other details might include when the vehicle is due for service or service interval, and registration renewal.

4.2.4. **Jobs required**

A very clear and precise job description and detailed explanation of the issues including the history of the issue, if any. If any doubts remain about any issues, the technician working on the job may need to contact and talk to the right person to gain all the information to correctly diagnose the vehicle.

4.2.5. **Time the vehicle is required by the customer**

This is important for all technicians to know so priority can be given to jobs

4.3. **There should be space on the job card for this kind of information:**

4.3.1. **Parts used on the job**

This could include part numbers, description and quantity. Any part not on the job card might get left off the invoice and therefore lower profitability.

4.3.2. **Work performed**

This must be in detail. Technicians may have to be taught the importance of this information, because it directly influences the invoiced amount. If a technician encounters a problem with a job, they should inform the right person as well as write it on the job card. The time taken is as important as the information on the type of work performed. You could have a section on the job card for recommended time for certain jobs. This can be useful where a technician becomes expert at a particular repair through experience and the time taken is reduced. In situations like this, it is not logical to reduce the invoice amount to match because the repair job still should retain its full value, regardless of how good a technician becomes at performing it.

4.3.3. **Service details**

These would include things like

- Brakes, including percentage of brake wear front and back, brake and clutch fluid test results.
- Tires, including tire size and percentage of wear on all tires including the spare, tire pressures before and after the service.
- Suspension, a good fair and fail option on front and back suspension.
- Timing belt – note whether the vehicle has a timing belt and if it has a service history.
- Drive belts – good, fair or fail on drive belts and tensioners.
- Coolant – good, fair or fail based on coolant testing.
- Fuel system inspection and overhaul
- Battery test results.
- Wiper blades – good, fair or fail on both front and back wiper blades. Windscreen washers – OK or fail on both front and back.
- Air conditioning – good, fair or fail and any service history.

There are probably more areas that can be covered in workshops that specialize in areas such as front end, auto electrical, automatic transmissions, exhaust, engine rebuilding and so on. Just think about the information you need at your fingertips to allow you to be more productive and more efficient, and then put a spot on your job card for it.

4.3.4. **Part suppliers**

A handy reference to trace where parts came from. Include a phone number, contact person, parts ordered or quote received, your price and retail price and time of order

4.3.5. **Report section**

This is a spot for technicians to write a report on other items found requiring attention or to expand or any issues already listed. This is where a note may be made to recheck something next service, or to highlight something quirky about the vehicle.

REF: 098-VEHICLE-JOB-CARD-A5-SET-PAD-BOOK
The GREEN TradePrintingUK watermarks are for proofing only and will not be printed on the job!

COMPANY NAME

Address
Tel: 0 **Fax:** 0
E-mail: 0 **Web:** 0
VAT Reg No. GB

VEHICLE JOB CARD

00001

TECHNICIAN:	CUSTOMER:
WORK ORDER:	REG No:
DEFECT NUMBER:	TRAILER / VEHICLE ID:
JOB DATE:	MILEAGE:
DAMAGE / WEAR & TEAR:	MOT DUE:
REPORTED DEFECT:	COMPLETED ACTION:
PARTS USED:	COST: LABOUR:
	TOTAL COST:

Self-Check 4	Written Test

Instruction: - chose and write the letter of the correct answer on the space provided or on the separate answer sheet (2 pts)

1. The formats of the Job card include?

A. Technicians name
B. Customer name
C. VIN
D. All of the above

Answer Sheet

Score = _____
Rating: _____

Name: _____ Date: _____

1 _____

Operation Sheet-1 Interpretation on Job Order Sheet

Instructions: You are required to interpret the Job Order provided and show to your Instructor the necessary preparation in order to accomplish the work according to the industry standards

SAMPLE JOB ORDER SHEET:

Dire Motor works		Date:	
Engine Description:		Model:	Year:
Item	Particulars		
1.	Service Fuel Filter		
2.	Bleeding of Diesel Fuel System		
3.	Re-tightening of Injectors		
4.	Glow Plug change		
5.	Clean fuel system		
Repair undertaken by: sign.			

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Task 1: prepare job card

List of Reference Materials

References

denton, t. (2012). *Advanced automotive fault diagnosis.* New York: Routledge. Retrieved from https://www.pdfdrive.com/advanced-automotive-fault-diagnosis