Vehicle Servicing and repairing
Level II

Learning Guide

Unit of Competence: Inspect and Servicing Engine Systems

Module Title: Inspecting and Servicing Engine Systems

LG Code: EIS VSR2 M02 L03 LG
TTLM Code: EIS VSR2 TTLM 0919v1

LO3: service on engine system

Instruction Sheet	Learning Guide

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

- Analyze and select Service options
- Select and prepare techniques, tools and materials
- Carry out service adjustments
- Carry out post-service testing.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Appropriate service options in accordance with work requirement.
- Select and prepare techniques, tools and materials in accordance with manufacturer instructions.
- Carry out service adjustments and post-service testing in accordance with manufacturer instructions.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 7.
3. Read the information written in the “Information Sheets Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” in the module.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “learning guide”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to “Information Sheets”.
7. Submit your accomplished Self-check in module. This will form part of your training portfolio.
8. Read the information written in the “Learning Guide”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
9. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work

3.1. Analyze and select Service options.

3.1.1. Lubrication system

The moving parts of an engine need constant lubrication. Lubrication limits the amount of wear and reduces the amount of friction in the engine. **Friction** is heat generated when two objects rub against each other.
Motor or engine oil is the fluid used to lubricate the engine. Several quarts of oil are stored in an **oil pan** bolted to the bottom of the engine block. The oil pan is also called the crankcase or **oil sump**.

Oil pump

The oil pump is the heart of the lubricating system. Just as the heart in a human body circulates blood through veins, an engine's oil pump circulates oil through passages in the engine. The oil pump pickup is a line from the oil pump to the oil stored in the oil pan. It usually contains a filter screen, which is submerged in the oil at all times. The screen serves to keep large particles from reaching the oil pump. This screen should be cleaned any time the oil pan is removed. The pickup may also contain a by-pass valve that allows oil to enter the pump if the screen becomes totally plugged.

When the engine is running, an oil pump draws oil from the pan and forces it through oil galleries. These galleries are small passageways that direct the oil to the moving parts of the engine. Oil from the pan passes through an oil filter before moving through the engine **(Figure 3.1)**.

The filter
removes dirt and metal particles from the oil. Premature wear and damage to parts can result from dirt in the oil. Regular replacement of the oil filter and oil is an important step in a preventive maintenance program.

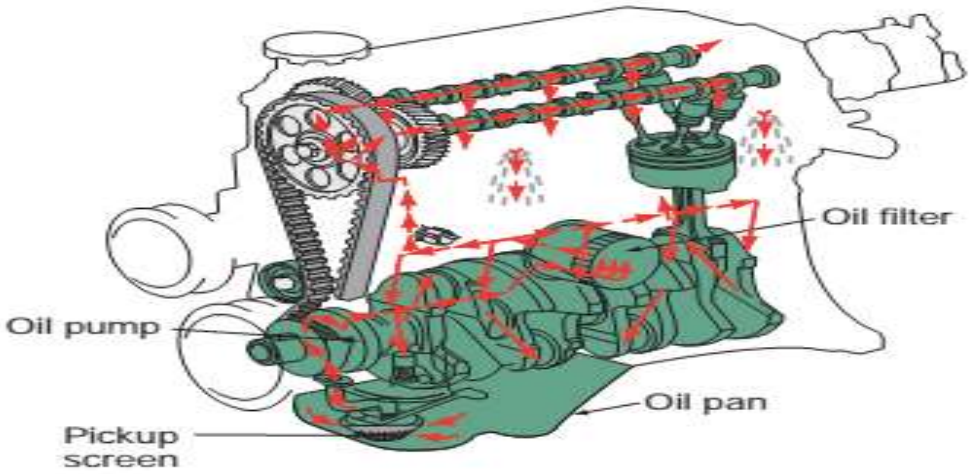


Figure 3.1 Oil flow in a typical engine's lubrication system.

3.1.1. Pressure switch

Because the oil pump is a positive displacement pump, an oil pressure relief valve is used to prevent excessively high system pressures from occurring as engine speed is increased. Once oil pressure exceeds a present limit, the spring-loaded pressure relief valve opens and allows the excess oil to bypass the rest of the system and return directly to the sump.

3.1.1.2. Pressure test

Oil Pressure Testing

An oil pressure test is used to determine the wear of an engine's parts. The oil pressure test is performed with an oil pressure gauge, which measures the pressure of the oil as it circulates through the engine. Basically, the pressure of the oil depends on the efficiency of the oil pump and the clearances through which the oil flows. Excessive clearances, most often caused by wear between a shaft and its bearings, will cause a decrease in oil pressure.

Loss of performance, excessive engine noise, and poor starting can be caused by abnormal oil pressure. When the engine's oil pressure is too low, premature wear of its parts will result. An oil pressure tester is a gauge with a high pressure hose attached to it. The scale of the gauge typically reads from 0 to 100 psi (0 to 690 kPa). Using the correct fittings and adapters, the hose is connected to an oil passage in the engine block. The test normally includes the following steps:

1. Remove the oil pressure sensor and tighten the threaded end of the gauge's hose into that bore.
2. Run the engine until it reaches normal operating temperature.

3. Observe the gauge reading while the engine is running at about 1,000 rpm and at 2,500 rpm (or the specified engine speed).
4. Compare the readings to the manufacturer's specifications.

Excessive bearing clearances are not the only possible causes for low oil pressure readings; others are oil pump-related problems, a plugged oil pickup screen, weak or broken oil pressure relief valve, low oil level, contaminated oil, or low oil viscosity.

All vehicles have an oil pressure gauge and/or a low-pressure indicator light. Oil gauges are either mechanically or electrically operated and display the actual oil pressure of the engine. The indicator light only warns the driver of low oil pressure. In a mechanical gauge, oil travels up to the back of the gauge where a springy, flexible, hollow tube, called a Bourdon tube, uncoils as the pressure increases. A needle attached to the Bourdon tube moves over a scale to indicate the oil pressure. Most pressure gauges are electrically controlled. An oil pressure sensor or sending unit is screwed into an oil gallery. As oil passes through an oil pressure sender (Figure 3.2), it moves a diaphragm, which is connected to a variable resistor. This resistor changes the amount of current passing through the circuit. A gauge on the dashboard reacts to the current and moves a needle over a scale to indicate the oil pressure, or the current is translated into a digital reading on the gauge.

Warning light systems are basically simple electrical circuits. The indicator light comes on when the circuit is completed by a sensor. This sensor has a diaphragm connected to a switch inside the sensor. Under normal conditions, the sender switch is open. When oil pressure falls below a certain level, the reduction of pressure causes the diaphragm to move and close the sender switch (Figure 3.3), which completes the electrical circuit. When this happens, electricity flows and turns on the warning light on the dashboard.

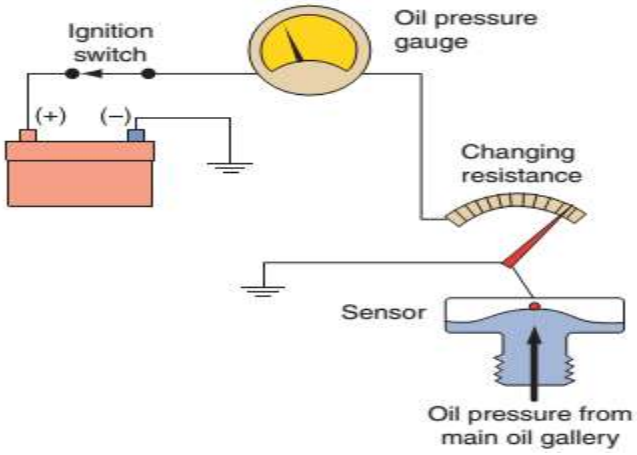


Figure3.2. As oil pressure changes, the resistance in for a warning gauge
pressure gauge circuit and the reading on the gauge change accordingly.

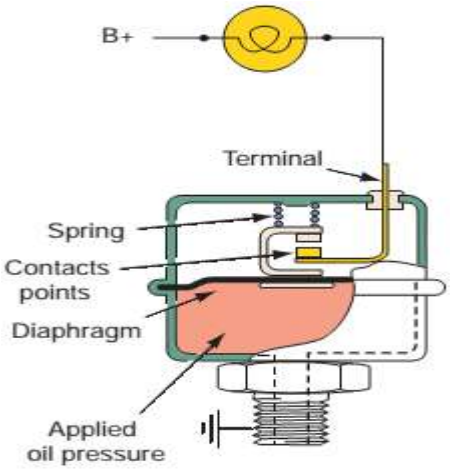


Figure 3.3. Oil pressure sensor
the oil

The oil pressure gauge is installed into the oil pressure sending unit's bore in the engine block.

3.1.1.3. Oil quality check

Engine Oil

Engine oil is a clean or refined form of crude oil. **Crude oil**, when taken out of the ground, is dirty and does not work well as a lubricant for engines. Crude oil must be refined to meet industry standards. Engine oil (often called motor oil) is just one of the many products that come from crude oil. Engine oil is specially formulated so that it:

- Can flow easily through the engine
- Provides lubrication without foaming
- Reduces friction and wear
- Prevents the formation of rust and corrosion
- Cools the engine parts it flows over
- Keeps internal engine parts clean

Engine oil contains many additives, each intended to improve the effectiveness of the oil. **The American Petroleum Institute (API)** classifies engine oil as

ENGINE OIL SERVICE RATINGS	
RATING	**COMMENTS**
SA	Straight mineral oil (no additives), not suitable for use in any engine
SB	Non-detergent oil with additives to control wear and oil oxidation

SC	Obsolete since 1964
SD	Obsolete since 1968
SE	Obsolete since 1972
SF	Obsolete since 1980
SG	Obsolete since 1988
SH	Obsolete since 1993
SJ	Obsolete since 1997
SL	Started in 2001
SM	Started in 200

Table3.1. Engine oil ratings

Standard or S-class for passenger cars and light trucks and as commercial or C-class for heavy-duty commercial applications. The various types of oil within each class are further rated according to their ability to meet the engine manufacturers' warranty specifications (Table 7–1). Engine oils can be classified as **energy-conserving** (fuel-saving) **oils**. These are designed to reduce friction, which in turn reduces fuel consumption. Friction modifiers and other additives are used to achieve this.

In addition to the API rating, oil **viscosity** is important in selecting engine oil. The ability of oil to resist flowing is its viscosity. The thicker the oil, the higher its viscosity rating. Viscosity is affected by temperature; hot oil flows faster than cold oil. Oil flow is important to the life of an engine. Because an engine operates under a wide range of temperatures, selecting the correct viscosity is very important.

The **Society of Automotive Engineers (SAE)** has established an oil viscosity classification system that is accepted throughout the industry. This system is a numeric rating in which the higher viscosity, or heavier weight, oils receive the higher numbers. For example, oil classified as SAE 50 weight oil is heavier and flows slower than SAE 10 weight oil. Heavyweight oils are best suited for use in high-temperature regions. Low-weight oils work best in low-temperature operations.

Figure 3.4 The **SAE** classification and the **API** rating are displayed in this way on a container of oil.

Although single viscosity oils are available, most engine oils are **multiviscosity** oils. These oils carry a combined classification such as **10W-30**. This rating says the oil has

the viscosity of both a 10- and a 30-weight oil. The “W” after the 10 notes that the oil’s viscosity was tested at 0°F (–18°C). This is commonly referred to as the “winter grade.” Therefore, the 10W means the oil has a viscosity of 10 when cold. The 30 rating is the hot rating. This rating was the result of testing the oil’s viscosity at 212°F (100°C). To formulate multiviscosity oils, polymers are blended into the oil. Polymers expand when heated. With the polymers, the oil maintains its viscosity to the point where it is equal to 30-weight oil. The SAE classification and the API rating are displayed on the container of oil (Figure 3.4).

ISLAC Oil Ratings the International Lubrication Standardization and Approval Committee (ISLAC) has developed an oil rating that combines SAE viscosity ratings and the API service rating. If engine oil meets the standards, a “sunburst” symbol is displayed on the container (Figure 3.5). This means the oil is suitable for use in nearly any gasoline engine

Figure 3.5 The **ILSAC** certification mark, commonly referred to as “the Starburst.”

Note: - Many engines have very specific requirements. Always install the type of oil specified by the manufacturer. Never assume that a particular type of oil can be used in an engine.

JOB SHEET LO3-1

Service lubrication system.

TITLE: ENGINE OIL AND FILTER CHANGE

PUROSE: To carry out procedure in changing engine oil, and replace oil filter.

Safety Items and Special Equipment

- ♦ Safety glasses or goggles
- ♦ Oil filter wrench
- ♦ Oil catch pan

Procedure

1. Start engine in a well-ventilated area and allow it to reach normal operating temperature. Shut off the engine.

2. Safely raise vehicle on a hoist or support vehicle on jack stands.

SAFETY CAUTION: When hot, exhaust system parts, can cause severe burns. Avoid touching exhaust system parts. In addition, drain plugs and oil are hot enough to cause pain and minor burns. Use a shop towel to hold the drain plug as it is unscrewed, and avoid getting oil on yourself during draining.

3. Loosen drain plug with a wrench. Do not unscrew plug.

4. Position an oil catch pan under oil pan drain pug.

5. Unscrew and remove drain plug by hand. Allow hot oil to drain into the catch pan for at least five minutes.

6. Clean drain plug and mounting hole with a shop towel. Thread plug in by hand, and then tighten as recommended by vehicle manufacturer.

7. Position oil catch pan under oil filter.

8. Loosen oil filter with an oil filter wrench. Unscrew filter by hand and place in catch pan to drain. Clean oil filter mounting surface with a shop towel.

10. Rub a few drops of new engine oil onto rubber gasket of oil filter.

11. Screw filter on by hand. After rubber gasket contacts mounting surface, turn filter an additional ¾ to 1 full turn by hand.

12. Lower vehicle and add correct amount of new engine oil. Start engine and watch oil pressure warning light or gauge until normal pressure is indicated. Check for leaks around filter and drain plug. Shut off engine.

13. Wait five minutes, then check engine oil dipstick for proper oil level.

Job Completion Report

1. What size wrench was necessary to loosen the drain plug?_____

2. List filter make and code number for this vehicle:_____

3. What quantity of oil is necessary for an oil change with and without a filter change for this
vehicle? With filter_____ without filter_____

4. What problems, if any, were encountered during this
procedure?_____
_____
_____
_____
_____

Self-check 1.

Write short answer for the following questions.

1. Write the purpose of lubrication system.

2. Write the components of lubrication system with their function.

3. Define the following terms

- **API**

- **SAE**

- **ISLAC**

3.1.2 Cooling system

Introduction

The cooling system keeps the engine at its most efficient temperature at all speeds and operating conditions. Burning fuel in the engine produces heat. Some of this heat must be taken away before it damages engine parts. This is one of the three jobs performed by the cooling system. It also helps bring the engine to normal operating temperature as quickly as possible. In addition, the cooling system provides a source of heat for the passenger compartment heater.

There are two types of cooling systems found on cars: liquid-cooled and air-cooled.

Liquid Cooling

The cooling system on liquid-cooled cars circulates a fluid through pipes and passageways in the engine. As this liquid passes through the hot engine it absorbs heat, cooling the engine. After the fluid leaves the engine, it passes through a heat exchanger, or radiator, which transfers the heat from the fluid to the air blowing through the exchanger.

Air Cooling

Some older cars, and very few modern cars, are air-cooled. Instead of circulating fluid through the engine, the engine block is covered in aluminum fins that conduct the heat away from the cylinder. A powerful fan forces air over these fins, which cools the engine by transferring the heat to the air.

Cooling-System Components and their Functions

3.1.2.1. Radiator – heat exchanger that removes heat from coolant passing through it; receives hot coolant from the engine and returns the coolant to the engine at a lower temperature.

3.1.2.2. Fan (Engine Fan or Cooling Fan) – pulls or pushes the additional air through the radiator. It may be either a mechanical fan or an electric fan.

3.1.2.3. Thermostat – a heat-operated valve that regulates the flow of liquid-coolant between the engine and the radiator, thereby controlling coolant temperature; a control device containing a temperature-sensitive element that automatically reacts to temperature changes by bending and straightening, or expanding or contracting.

3.1.2.4. Water Pump – an engine-driven centrifugal pump that circulates coolant between the engine water jacket and the radiator.

3.1.2.5. Drive Belt – a continuous loop of reinforced rubber used to transmit power between to shafts.

The Cooling System and Its Effects to the Engine

The cooling system is often neglected. A customer will spend a great deal of money on an overhaul but will not get a complete repair if the cooling system is not put in good order. Radiators often become plugged or rotten. If the radiator cannot conduct enough heat away, the engine will overheat.

The following may cause overheating to the engine and have to be checked:

1. Low coolant level

2. Loose belt (belt-driven water pump)

3. Defective pressure cap

4. Defective thermostat

5. Idle speed too low

6. Defective thermal control fan

7. Defective electric fan circuit

8. Plugged radiator coolant passages

9. Plugged air passages in the radiator

10. Defective water pump

11. Defective cylinder heated gasket

3.1.3. Fuel system

SELF-CHECK LO3-2

A. Directions: Answer the following as indicated. Write your answers on the answer sheet provided by your instructor.

1. What are the two types of cooling system?

2. What type of cooling system is that wherein heat is removed from around the combustion chambers by a heat-absorbing liquid (coolant) circulating inside the engine?

3. What is the type of cooling system which employs air rather than liquid as the medium to transfer heat from the engine components to the atmosphere?

4. Enumerate at least 5 components/parts of the cooling system.

B. Directions: Give the functions of the following cooling system components/parts. Answer in complete sentences. Write your answers on the answer sheet provided.

1. Radiator

2. Cooling fan

3. Water pump

4. Water jacket

5. Thermostat

6. Drive belt

Diesel-Engine Fuel Systems

Figure 3.6 shows a typical automotive diesel-engine fuel system. It uses injection nozzles or injectors similar to the fuel injectors in gasoline fuel-injection systems. The gasoline injectors are solenoid operated. When high pressure is applied, they open and spray fuel. The diesel fuel system must:

1. Deliver the right amount of fuel to meet the operating requirements.

2. Time the opening of the injection nozzles so the fuel enters the engine cylinders at the proper instant. As engine speed increases, fuel injection must start earlier. This gives the fuel enough time to burn and produce pressure on the pistons. Without the advance, the pistons would be over TDC and moving down before the fuel fully ignites. This wastes fuel and power.

3. Deliver the fuel to the cylinders under high pressure. Injection pressure must be high enough to overcome the high compression pressure in the diesel engine. At the end of the compression stroke, compression pressure may be 500 psi [3447 kPa] or higher.

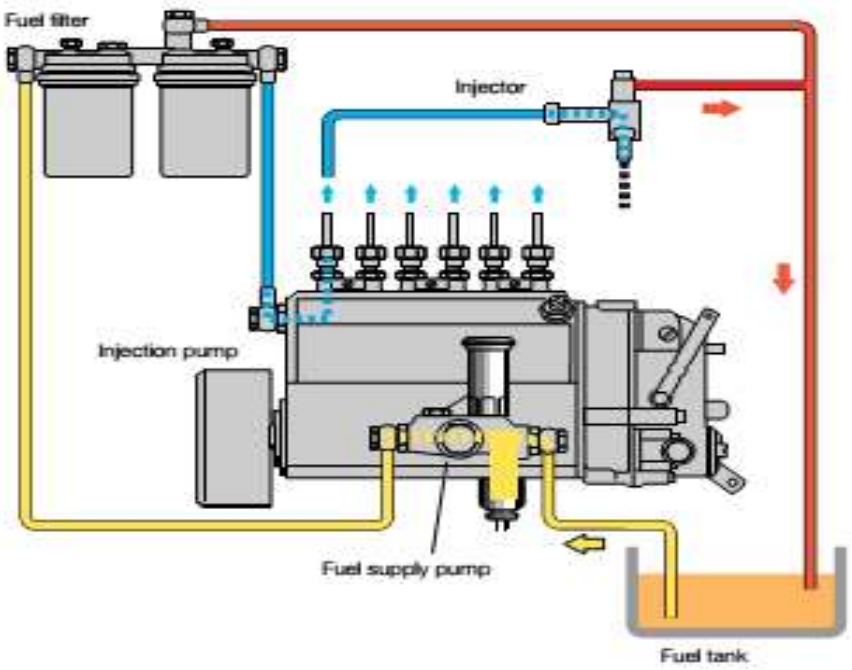


Figure 3.6. Typical fuel system for an automotive diesel engine.

FUEL delivery SYSTEM

The fuel delivery system has the important role of delivering fuel to the fuel injection system. The fuel must also be delivered in the right quantities and at the right pressure. The fuel must also be clean when it is delivered.

A typical fuel delivery system includes a fuel tank, fuel lines, fuel filters, and a pump (Figure 3.7). The system works by using a pump to draw fuel from the fuel tank and passing it under pressure through fuel lines and filters to the fuel injection system. The filter removes dirt and other harmful impurities from the fuel. A fuel line pressure regulator maintains a constant high fuel pressure. This pressure generates the spraying force needed to inject the fuel. Excess fuel not required by the engine returns to the fuel tank through a fuel return line.

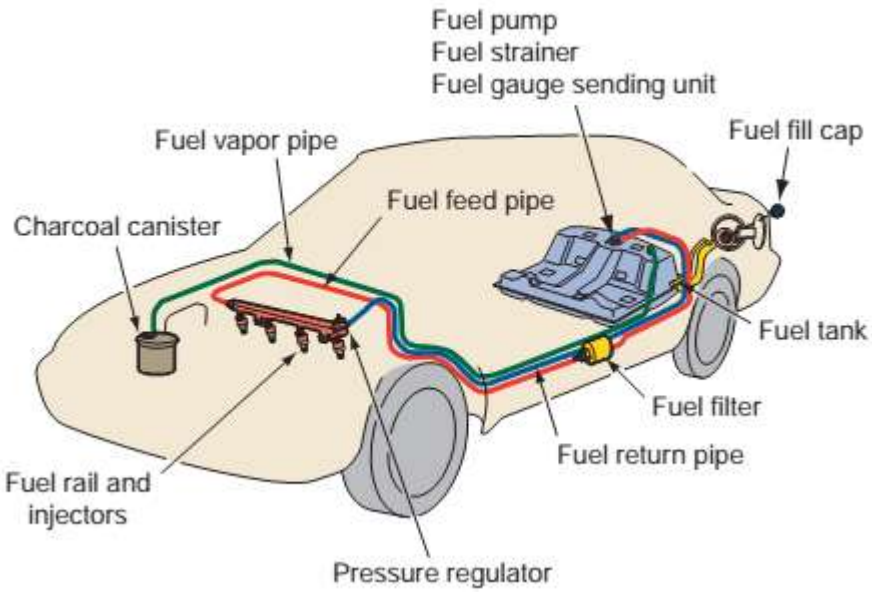


Figure3.7. The fuel delivery system for a late-model car.

Fuel tank

The fuel tank on commercial vehicles is often made of aluminum or plastic for reasons of weight. It must be corrosion resistant and remain tight at double its operating pressure (legally specified minimum value = 0.3 bar overpressure). Larger tanks often incorporate baffle plates to prevent the fuel from being displaced excessively when cornering, braking and moving away. The drain plug is positioned at the lowest point in the tank.

Fuel lines

Steel pipes or plastic fuel lines are used on the diesel engines of commercial vehicles.

Fuel supply pump

The fuel supply pump transfers the fuel from the tank to the injection pump. On the inline injection pumps often used on commercial vehicles, the fuel supply pump is a

piston-type pump. It is flanged onto the injection pump and usually equipped with a hand-operated pump for venting the fuel system. Its task is to deliver the fuel to the injection pump at a pressure of approx. 1 - 2.5 bar. The supply pump is driven by a cam located on the injection pumps camshaft. The higher the pressure in the supply line, the less fuel is pumped. This is known as flexible delivery. Distributor pumps have integral supply pumps which take the form of vane pumps or separate diaphragm pumps.

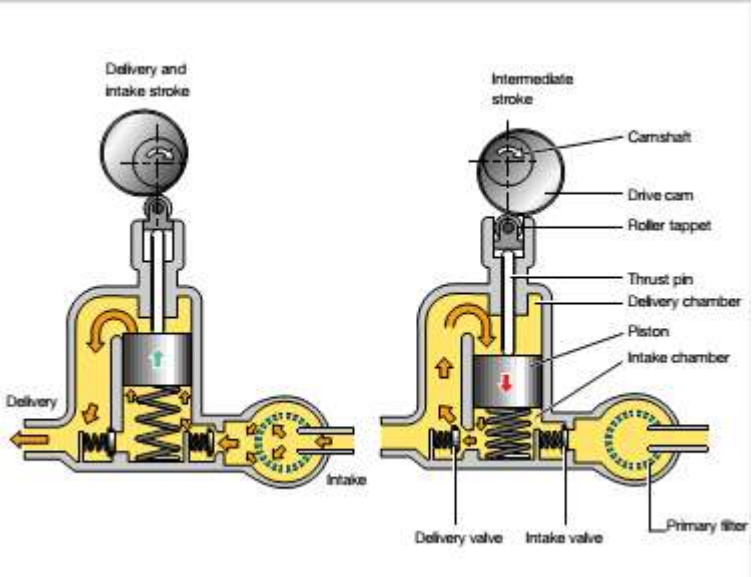


Fig 3.8 fuel supply pump

Fuel filter

For optimum operation and service life of the diesel fuel injection system, it is essential that the diesel fuel be carefully filtered. The components of the injection pump and the injectors themselves are manufactured to a precision of a few thousandths of a millimetre. Fuel filters must filter out impurities of even this small size if the efficiency of the fuel injection system is not to be impaired. The consequences of poorer fuel quality as a result of contaminated filters are:

- Poorer combustion,
- Poor starting behavior,
- Low engine output,
- Lumpy idling,
- High fuel consumption.

The filter element must be changed at the specified interval (approx. 30,000 km).

Fig 3.9 fuel filter

Fuel injection system

Depending on the diesel combustion method used, the fuel must be injected into the combustion chamber at a pressure of between 350 and 1600 bar. The fuel must in addition be metered with extreme accuracy.

The principal defining characteristics of a modern commercial-vehicle diesel engine are its fuel consumption, pollutant emissions and noise emissions. For these parameters to be ideally matched, the start of delivery has to take place with an accuracy of approx. +- 1 °CS. Important criteria for the fuel injection processes are:

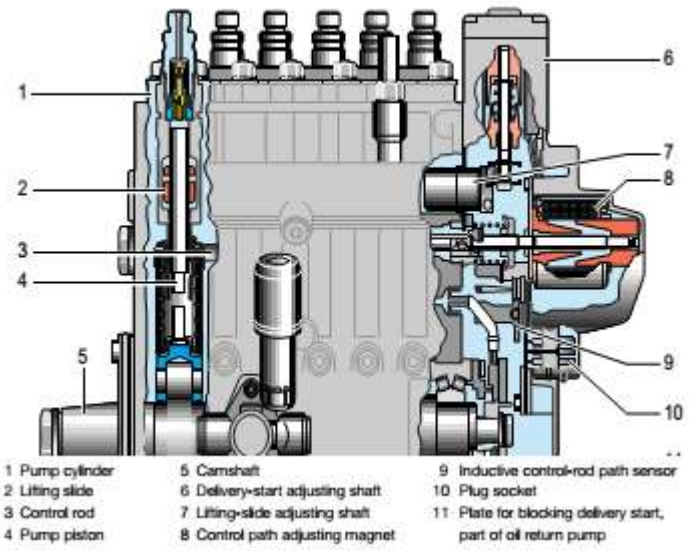
- Timing and duration of fuel injection,
- Fuel distribution in the combustion chamber,
- Timing of start of combustion,
- Amount of fuel metered per °CS,
- Overall amount of fuel metered.

Inline injection pumps

Inline injection pumps have a separate camshaft and one pump element per engine cylinder. The stroke of the pistons always remains the same. The pump rate is regulated via metering ramps. The fuel is pumped through a separate high-pressure line to the corresponding injector for each cylinder of the engine. The injection pumps camshaft, driven by the engine, controls the injection processes in the individual injectors.

A mechanical injection timing device adjusts the start of delivery according to engine speed, as necessary. It rotates the camshaft in relation to the engine crankshaft, thus

displacing the start of delivery. The inline injection pump is connected up to the engine oil circuit for lubrication of the moving pump components.



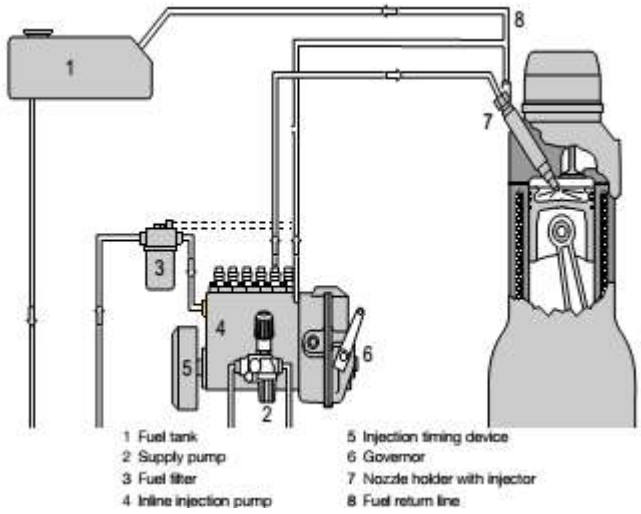


Fig 3.10 Operating principle of the lifting-slide inline injection pump & mechanical in line pump

Distributor-type pumps

Unlike the inline injection pump, the distributor-type pump has only one pump element with one piston for all cylinders. The piston operates as many strokes as there are cylinders for every revolution of the crankshaft. The simultaneous movement of the piston during the stroke distributes the fuel to the various inlets and pumps it to the

corresponding injectors. A mechanical speed governor and a hydraulic injection timing device are integrated into the distributor pumps housing. Distributor-type pumps are used on high speed passenger-car and commercial vehicle diesel engines with an output per cylinder of up to 25 kW. The injection pressure is approximately 700 bars. Distributor type pumps with electronic control are capable of injection pressures as high as 1400 bar.

Bleeding

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.

5. After repairing or replacing any fuel line.

6. Before putting engine back into service in the spring, if fuel system has been drained.

7. Replacement of electric or mechanical fuel pump.

8. Any time air is permitted to enter the fuel system.

BLEEDING PROCEDURE:

Be sure to have some means available to catch or absorb any fuel escaping during the bleeding process so that it will not accumulate in the engine compartment or bilge.

1. be sure there is a sufficient supply of fuel in the fuel tank.

2. Open the fuel shut-off valve at the tank.

3. Start the electric fuel pump by turning the ignition key to the "ON" position on models 18, 20, 25, 30, 50, all models after 1986.

4. Model 15 has a mechanical fuel pump. Therefore with decompression on, turn engine over with starter. Crank at 10 second intervals while doing steps #5 and 7.

5. Slowly loosen the air bleed plug on the fuel filter, letting air escape until an air free flow of fuel is evident. (1986 models see item 7).

6. At this time, tighten the air bleed plug on the filter.

7. Slowly loosen the air bleed plug on the injector pump, letting air escape until an air free flow of fuel is evident. Units with a self-bleed return valve open for a short period then start engine, as soon as engine runs smooth close valve. Model-12 has continuous fuel bleeding.

8. At this time, tighten the air bleed plug or knurled knob on the injector pump.

9. The fuel system should now be properly bled and ready for operation. Refer to starting instructions before attempting to start the engine after bleeding the fuel system.

CAUTION: Excessive cranking with seal cock valve open can cause water accumulation in the muffler and possibly back up into the engine. Drain muffler as needed.

FUEL INJECTORS:

Fuel injectors should be removed and taken to a qualified diesel engine repair center to be tested for leakage and spray pattern, if poor engine performance such as loss of power, rough or uneven running, sudden notice of dark exhaust, or engine becomes hard to start.

REMOVING INJECTORS:

1. Clean the area around the injectors before removing.

2. Loosen nuts holding fuel lines to injector pump and injector nozzle and remove fuel lines.

3. Loosen nuts on return line adapters and remove adapters.

4. Loosen injectors and remove injectors.

REPLACING INJECTORS:

1. Check to be sure contacts surfaces and area around injectors is clean.

2. Replace injectors in the same cylinder from which they were removed.

3. Torque required to properly seat the injectors will be between 43 and 58 ft./lbs.

4. Replace fuel return lines and secure nuts.

5. Replace all fuel lines and secure all nuts.

6. After all injectors, fuel lines and hoses have been replaced and are secured, the fuel system will have to be bled.

The fuel injection pump has been set at the factory and should need no adjustment. Any apparent problem with the pump should be referred to a qualified diesel mechanic or to a Universal Diesel dealer as advised.

NOTE: NO WARRANTY COVERAGE WILL BE GRANTED IF ANY OF THE FACTORY SET AND SEALED FUEL AND MAXIMUM RPM. ADJUSTMENTS ARE ALTERED.

Injection timing

TIMING DEVICE

A large percentage of fuel injection pumps have timing devices incorporated in them. Varying the time when fuel injection begins will improve diesel engine performance and fuel economy, for the same reason that varying spark timing will improve the performance of a gasoline engine.

1. The timing device usually consists of an aluminum casting with mounting flanges at both ends. A bore in the housing guides and supports the spider assembly. A timing opening, with a cover, is located in the top of the housing and is used to observe the position of the timing pointer in relation to the timing mark on the timing device hub during injection pump timing procedures.
2. The timing device hub, with external left-hand helical splines for engaging the internal helical splines of the sliding gear, has a tapered bore and keyway. The hub is secured to the camshaft extension by a woodruff key, nut, and setscrew. The hub is usually counter bored to receive the timing device springs. The springs oppose the fly weight forces of the weight and spider assembly.
3. The weight and spider assembly has external right-hand helical splines which mesh with the internal helical splines of the sliding gear. The splined end is machined to receive the end play spacer. Three flyweights are pinned to a flange adjacent to the splines. The weight and spider thrust plate, located between the flange and the timing device housing, carries the back thrust of the flyweights and prevents housing wear.
4. The sliding gear has internal left-hand helical splines at one end and internal right hand helical splines at the other, and meshes with the external splines of both the weight and spider assembly and the timing device hub. Correct assembly of the spline train is ensured by a wide land on both the hub and weight and the spider assembly. The sliding gear has a missing tooth on each set of internal splines to receive the wide lands.

   Three arms extend from the outer surface of the sliding gear to provide seats for the three timing device springs. The force on these springs is controlled by a sliding gear spacer.

Operation:

1. As the engine rotates the weight and spider assembly, centrifugal force opens the flyweights from their collapsed position against the force of the three timing device springs.
2. As the flyweights swing out, the sliding gear is forced toward the timing device hub.
3. The longitudinal movement of the sliding gear on its helical spline causes a slight change in the rotational relationship of the injection pump to the engine, causing injection to begin slightly earlier in the power stroke.

OPERATION SHEET: TIMING THE FUEL INJECTION PUMP

Note: Unless major repair work is done on the engine, timing should not be required.

Four cylinder firing order - 1 - 3 - 4 – 2

Procedure:

1. Remove fuel lines from injector pump fittings on injector pump (Tool).
2. Pull the decompression lever so that it will remain in the decompression position. No decompression lever on Model-12
3. Open throttle fully.
4. Energize the electric fuel pump and turn engine over with starter to ensure that fuel is coming out of each injector pump opening. Have clean rags around opening to soak up fuel.
5. Wipe off any fuel on injector pump body and the top of each injector opening.
6. Turn crankshaft over by hand, being careful not to damage spline on end of crankshaft. Engine rotation will be clockwise. STOP IMMEDIATELY at the first sign of fuel movement in the injector pump fuel fitting, for whichever injector pump is being checked. (No. 1 injector pump is the closest to the V-belt end of the engine).
7. Remove the cover from flywheel timing mark inspection hold located inside of left engine mount (Tool B).
8. Check alignment of mark on flywheel with the timing pointer on the wall of the inspection hole. The 1-Fl mark on the flywheel represents fuel injection of No. 1 cylinder. 2-Fl represents No. 2 cylinder, etc.
9. If timing pointer and the flywheel marking 1-Fl is aligned then No. 1 cylinder is properly timed for fuel injection and should require no adjustment. The same will be true for No. 2, No. 3 and No. 4 cylinders if the above steps are followed.
10. In order to determine if timing is off, or if the injection pump is faulty, it is necessary to recheck the timing for each cylinder two or three times. If there are variations in repeatability in the alignment of pointer and timing mark, a faulty fuel injector pump may be suspected.
11. If timing marks repeat to same location but are off 3/16" or more above or below the pointer, this indicates that the engine must be retimed.

If alignment of the timing mark is not within 3/16" above or below the pointer, the above steps must be taken to time the engine. If the timing is found to be satisfactory, then reconnect all fuel lines and fittings and tighten.

The fuel system must be bled before the engine will operate properly.

Fuel pressure test

The fuel pressure test is the commonly used test for the fuel pump and related parts. Before connecting this test, carefully inspect the system for leaks and repair them before continuing. Then relieve the pressure in the system. When doing this, make sure to collect all spilled fuel. Scan tools can be used to shut down the fuel pump on many systems.

Fuel pressure is read with a fuel pressure gauge. The proper procedure for testing fuel pump pressure is shown in Photo Sequence 3.1-3.8 These photos outline the steps to follow while performing the test on an engine with fuel injection. To conduct this test on specific fuel injection systems, refer to the service manual for instructions. Most domestic systems have a Schrader valve on the fuel rail, which can be used to connect the fuel pressure gauge. If the system does not have a Schrader valve, a tee should be installed in the fuel supply line to connect the gauge (Figure 3.9 -1). On some engines, the fuel rail is fitted with a fuel pulsation damper. The point where the damper attaches to the fuel rail is the recommended place for connecting the pressure gauge. To connect the gauge, place a rag over the damper unit and loosen it one turn with a wrench. After all pressure is released, remove the damper unit and connect the gauge into the damper's fitting (Figure.3.9 -2)

P3.1. Many problems on today's cars can be caused by incorrect fuel pressure. Therefore, checking fuel pressure is an important step in diagnosing driveability problems.

P3.2. Prior to testing the fuel pump, a careful visual inspection of the injectors, fuel rail, and fuel lines and hoses is necessary. Any sign of a fuel leak should be noted and the cause corrected immediately.



P3.3. The supply line into the fuel rail is a likely point of leakage. Check the area around the fitting to make sure no leaks have occurred.

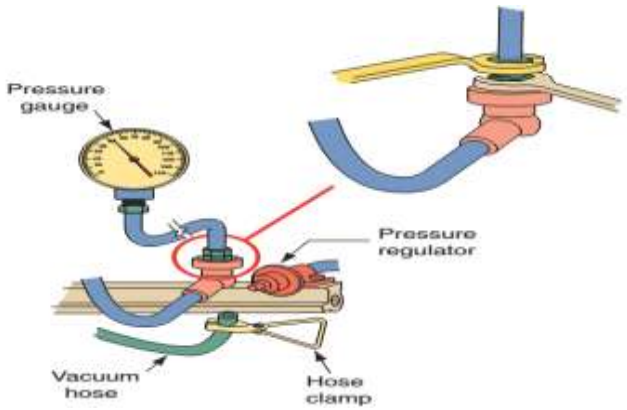
P3.4. Most fuel rails are equipped with a test fitting that can be used to relieve pressure and to test pressure.

P3.5. To test fuel pressure, connect the appropriate pressure gauge to the fuel rail test fitting (Schrader valve).



P3.6 Connect a hand-held vacuum pump to the fuel pressure regulator.

P3.7 Turn the ignition switch to the run position and observe the fuel pressure gauge. Compare the reading to specifications. A reading lowers than normal indicates a faulty fuel pumps or fuel delivery system.
P3.8 To test the fuel pressure regulator, create a vacuum at the regulator with the vacuum pump. Fuel pressure should decrease as vacuum increases. If pressure



remains the same, the regulator is faulty.

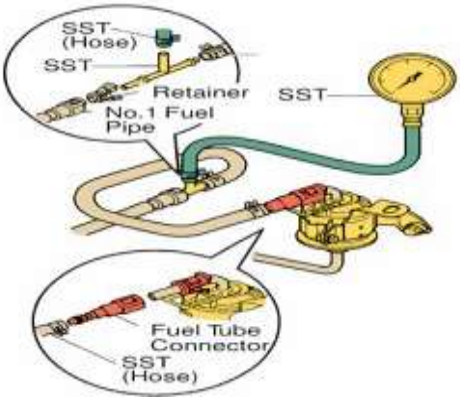


Figure 3.9. 1. On fuel systems that do not have a Schrader valve, it may be necessary to fit a tee in the fuel line to connect the fuel pressure gauge. 2. Connecting a fuel pressure gauge to the fuel pulsation damper fitting Courtesy of Toyota Motor Sales, U.S.A., Inc.

JOB SHEET LO3: SET AND INSTALL INJECTION PUMP TO ENGINE

1. Remove the injection pump

   a. Label the vacuum hoses and disconnect them from the injection pump. (See arrows)

Figure LO1-15

   b. Loosen the fuel filter union bolts and remove the one connected to the injection pump.

Figure LO1-16

   c. Remove the delivery pipes connected to the injection pump delivery valves and injection nozzles.

Figure LO1-17

   d. Loosen the bolts on the injection pump cover. These bolts also hold the injection pump.

Figure LO1-18

e. Hold and support the injection pump while removing the bolts.

Figure LO1-19

f. Pull out the injection pump from the cover.

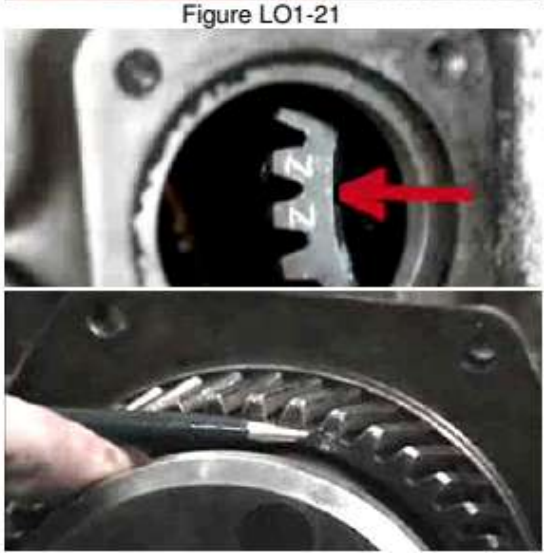
Figure LO1-20

Set the injection timing

a. Remove the timing mark cover.

Figure LO1-21

b. Find the marks on the idler gear and the injection pump gear.



c. Return the injection pump and align the timing marks of the injection pump gear and the idler gear.

Figure LO1-23

d. Inspect the position of the injection pump gear timing mark. It must be between the idler gear timing marks.

Figure LO1-24

e. Install the bolts holding the injection pump and tighten.

Figure LO1-25

f. Return the timing mark cover.

Select prepare techniques, tools and materials.

TITLE: ENGINE OIL AND FILTER CHANGE

Safety Items and Special Equipment

♦ Safety glasses or goggles

♦ Oil filter wrench

♦ Oil catch pan

References

Manufacturer's Service Manual

Repair Manual

Service Bulletin

Procedure

1. Start engine in a well-ventilated area and allow it to reach normal operating temperature. Shut off the engine.

2. Safely raise vehicle on a hoist or support vehicle on jack stands.

SAFETY CAUTION: When hot, exhaust system parts, can cause severe burns. Avoid touching exhaust system parts. In addition, drain plugs and oil are hot enough to cause pain and minor burns. Use a shop towel to hold the drain plug as it is unscrewed, and avoid getting oil on yourself during draining.

3. Loosen drain plug with a wrench. Do not unscrew plug.

4. Position an oil catch pan under oil pan drain pug.

5. Unscrew and remove drain plug by hand. Allow hot oil to drain into the catch pan for at least five minutes.

6. Clean drain plug and mounting hole with a shop towel. Thread plug in by hand, and then tighten as recommended by vehicle manufacturer.

7. Position oil catch pan under oil filter.

8. Loosen oil filter with an oil filter wrench Unscrew filter by hand and place in catch pan to drain.

9. Clean oil filter mounting surface with a shop towel.

10. Rub a few drops of new engine oil onto rubber gasket of oil filter.

11. Screw filter on by hand. After rubber gasket contacts mounting surface, turn filter an additional ¾ to 1 full turn by hand.

12. Lower vehicle and add correct amount of new engine oil. Start engine and watch oil pressure warning light or gauge until normal pressure is indicated. Check for leaks around filter and drain plug. Shut off engine.

13. Wait five minutes, then check engine oil dipstick for proper oil level.

P3-1 *Always make sure the vehicle is positioned safely on a lift or supported by jack stands before working under it. Before raising the vehicle, allow the engine to run awhile. After it is warm, turn off the engine.*

P3-2 *The tools and other items needed to change the engine's oil and oil filter are rags, a funnel, an oil filter wrench, safety glasses, and a wrench for the drain plug.*

P3-3 *Place the oil drain pan under the drain plug before beginning to drain the oil.*

P3-4 *Loosen the drain plug with the appropriate wrench. After the drain plug is loosened, quickly remove it so the oil can freely drain from the oil pan.*

P3-5 *Make sure the drain pan is positioned so it can catch all of the oil.*

P3-6 *While the oil is draining, use an oil filter wrench to loosen and remove the oil filter.*

P3-7 *Make sure the oil filter seal came off with the filter. Then place the filter into the drain pan so it can drain. After it has completely drained, discard the filter according to local regulations.*

P3-8 *Wipe off the oil filter sealing area on the engine block. Then apply a coat of clean engine oil onto the new filter's seal.*

P3-9 *Install the new filter and hand-tighten it. Oil filters should be tightened according to the directions given on the filter.*

P3-10 *Prior to installing the drain plug, wipe off its threads and sealing surface with a clean rag.*

P3-11 *Tighten the drain plug according to the manufacturer's recommendations. Overtightening can cause thread damage, whereas undertightening can cause an oil leak.*

P3-12 *With the oil filter and drain plug installed, lower the vehicle and remove the oil filler cap.*

P3-13 *Carefully pour the oil into the engine. The use of a funnel usually keeps oil from spilling on the engine.*

P3-14 *After the recommended amount of oil has been put in the engine, check the oil level.*

P3-15 *Start the engine and allow it to reach normal operating temperature. While the engine is running, check the engine for oil leaks, especially around the oil filter and drain plug. If there is a leak, shut down the engine and correct the problem.*

P3-16 *After the engine has been turned off, recheck the oil level and correct it as necessary.*

Self-check 3

Direction: Identify the following.

1. 

a. injection pipe
b. injection nozzle
c. fuel injector
d. injection pump

2. 

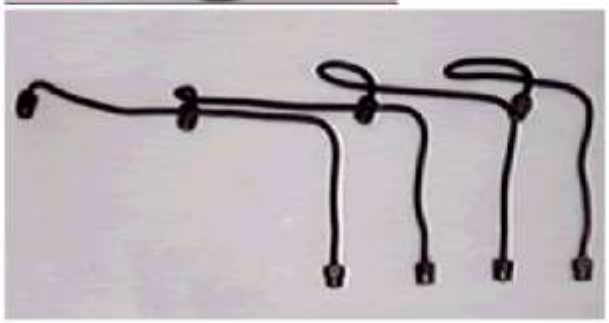
a. filter element
b. upper body
c. gasket
d. injection nozzle

3. 

a. injection pump
b. injector
c. injection nozzle
d. injection pipe

4. 

a. center bolt
b. fuel filter
c. filter element
d. filter housing

5. 

a. injector
b. injection pump
c. injection nozzle
d. injection pipe

Carry out service adjustments

Whenever you change an engine's oil, you should also do a visual inspection of the different systems under the hood, including the cooling system. Inspect all cooling system hoses for signs of leakage and/or damage. Replace all hoses that are swollen, cracked, or show signs of leakage. The radiator should also be checked for signs of leaks; if any are evident the radiator should be repaired or replaced. Also, check the front of the radiator for any build-up of dirt and bugs. This can restrict airflow through the radiator and should be removed by thorough cleaning.

The level and condition of the engine's coolant should also be checked. Check the coolant's level at the coolant recovery tank (Figure 7–11). It should be between the "low" and "full" lines. If the level is too low, more coolant should be added through the cap of the tank, not the radiator. Bring the level up to the "full" line. Always use the correct type of coolant when topping off or replacing it. Look at the color of the coolant when checking the level. It should be green, or perhaps orange, but it should not look rusty or cloudy. If the coolant looks contaminated, the cooling system should be flushed and new coolant put into the system.

Coolant Condition A coolant hydrometer is used to check the amount of antifreeze in the coolant. This tester contains a pickup hose, coolant reservoir, and squeeze bulb. The pickup hose is placed in the radiator coolant. When the squeeze bulb is squeezed and released, coolant is drawn into the reservoir. As coolant enters the reservoir, a pivoted float moves upward with the coolant level. A pointer on the float indicates the freezing point of the coolant on a scale located on the reservoir housing.

Drive Belts

Drive belts have been used for many years. V-belts and V-ribbed (serpentine) belts are used to drive water pumps, power steering pumps, air-conditioning compressors, generators, and emission control pumps. Heat has adverse effects on drive belts and they tend to over cure due to excessive heat. This causes the rubber to harden and crack. Excessive heat normally comes from slippage. Slippage can be caused by improper belt tension or oily conditions. When there is slippage, heat also travels through the drive pulley and down the shaft to the support bearing of the component it is driving. These bearings may be damaged if the slippage is allowed to continue.

V-belts ride in a matching groove in the engine's pulleys. The angled sides of the belt contact the inside of the pulleys' grooves. This point of contact is where motion is transferred. As a V-belt wears, it begins to ride deeper in the groove. This reduces its tension and promotes slippage. Because this is a normal occurrence, periodic adjustment of belt tension is necessary.

Drive belts can be used to drive a single part or a combination of parts. An engine can have three or more V-belts. In some cases, two matched belts are used on the same pulley set. This increases the strength of the belt and pulley connection and provides redundancy in case a belt breaks.

Inspection Even the best drive belts last only an average of 4 years. That time can be shortened by several things; most of these can be found by inspecting the belts. Check the condition of all of the drive belts on the engine. Carefully look to see if they have worn or glazed edges, tears, splits, and signs of oil soaking. If these conditions exist, the belt should be replaced. Also inspect the grooves of the drive pulleys for rust, oil, wear, and other damage. If a pulley is damaged, it should be replaced. Rust, dirt, and oil should be cleaned off the pulley before installing a new belt.

Misalignment of the pulleys reduces the belt's service life and brings about rapid pulley wear, which causes thrown belts and noise. Undesirable side or end thrust loads can also be imposed on pulley or pump shaft bearings. Check alignment with a straightedge. Pulleys should be in alignment within 1⁄16 inch (1.59 mm) per foot of the distance across the face of the pulleys.

Belt Tension A quick check of a belt's tension can be made by locating the longest span of the belt between two pulleys. With the engine off, press on the belt midway through that distance. If the belt moves more than ½ inch per foot of free span, the belt should be adjusted. Keep in mind that different belts require different tensions. The belt's tension should be checked with a belt tension gauge.

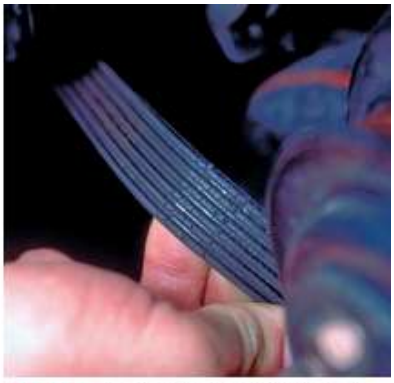
The tension should meet the manufacturer's specifications. Many engines are now equipped with a ribbed V-belt, which has an automatic tensioning pulley; therefore, a tension adjustment is not required.

USING SERVICE INFORMATION Proper belt tightening procedures and specifications are given in the specification section of most service manuals.

Typical Procedure for Inspecting, Removing, Replacing, and Adjusting a Drive Belt

P4-1 *Inspect the belt by looking at both sides.*

P4-2 *Look for signs of glazing.*



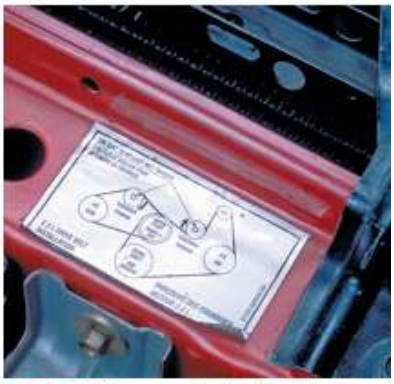
P4-3 *Look for signs of tearing or cracking.*

P4-4 *To replace a worn belt, locate the tensioner or generator pulley.*

P4-5 *Loosen the hold-down fastener for the tensioner or generator pulley.*

P4-6 *Pry the tensioner or generator pulley inward to release the belt tension and remove the belt.*

P4-7 *Match the old belt up for size with the new replacement belt.*



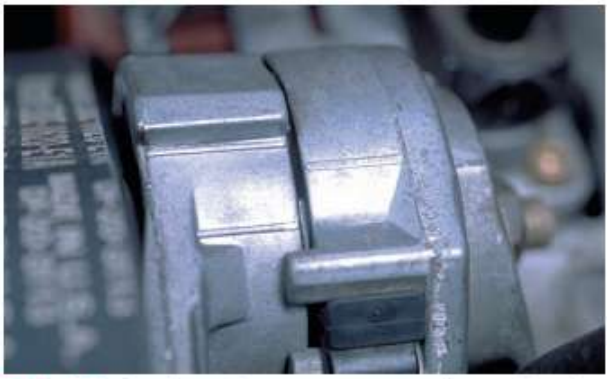
P4-8 *Observe the belt routing diagram in the engine compartment.*

P4-9 *Install the new belt over each of the drive pulleys. Often the manufacturer recommends a sequence for feeding the belt around the pulleys.*

P4-10 *Pry out the tensioner or generator pulley to put tension on the belt.*

P4-11 *Install the belt squarely in the grooves of each pulley.*

P4-12 *Measure the belt deflection in its longest span. If a belt tension gauge is available, use it and compare the tension to specifications.*



P4-13 *Pry the tensioner or generator pulley to adjust the belt to specifications.*

P4-14 *Tighten the tensioner or generator pulley fastener.*

P4-15 *Start the engine and check the belt for proper operation.*

Carry out post service testing

Table 2: DIESEL FUEL-INJECTION SYSTEM TROUBLE-DIAGNOSIS CHART

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	Retime 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 Retime 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 Clean 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

References

1. Automotive technology a system approach 5th edition (Jack Erjavec)
2. Toyota 2L-T, 3L engine repair manual
3. http//:www.google.engine top overhauling
4. auto mechanics books
5. Toyota service manual (engine mechanical)
6. http://www.austerclub.org/wp-content/uploads/Section-4-6.pdf
7. http://www.e34.de/tips_tricks/haynes/02b.pdf
8. The Goodheart-Willcox Co., Inc.
9. Heavy goods vehicle (HGV)inspection manual 2018 Edition
10. Fundamentals of commercial vehicle technology

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