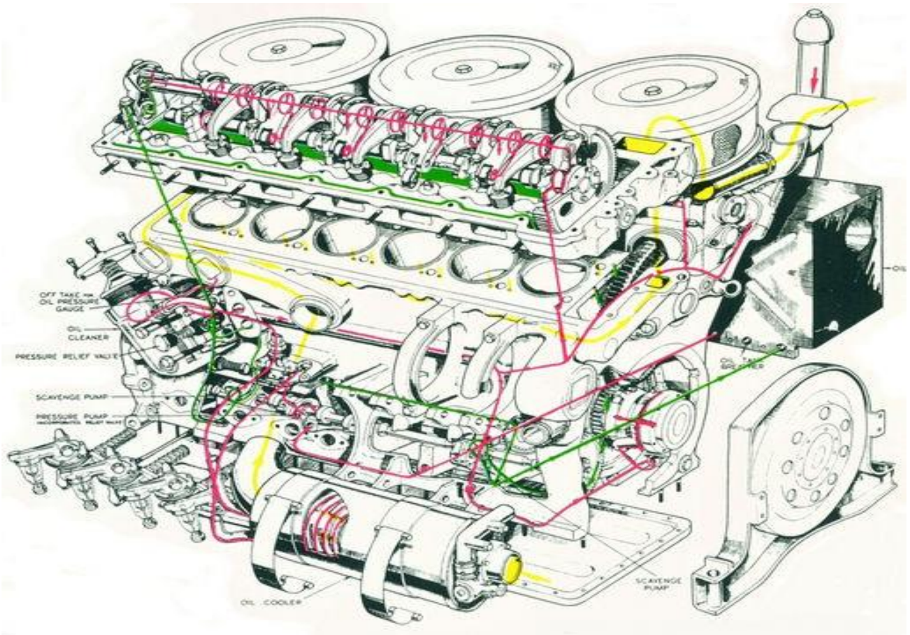
Automotive Mechanics

Level-II

Based on March 2022, Curriculum Version 1



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Acronym

CO	Carbon Monoxide
EC	External Combustion (IC)
HC	Hydro Carbon
HT	High tension cable
IC	Internal Combustion (IC)
ID	Identification
KPa	Kilo Pascal
LAP TEST	Learning Activity Performance Test
N2	Nitrogen
NOX	Oxide of Nitrogen
O	Oxygen
OHS	Occupational Health Safety
SAE	Society of Automotive Engineers
SAE 20W50	W- Milt-viscosity oil for winter Grade
SI	International Organization for Standardization
TTLM	Teaching, Training and Learning Materials
VIN	Vehicle identification number
EFE	Early Fuel Evaporation

Introduction to module

This module covers the knowledge, skills and attitude required to carry out minor services in automotive engines and associated sub-system assemblies. The module involves preparing for the task, basic checking/testing to identify fault, remove, disassemble, replace worn or failed components and assemblies and reinstall. Additionally, this module covers performing post-service checks and documentation.

This module is designed to meet the industry requirement under the automotive mechanics level II occupational standard, particularly for the unit of competency: **Service Engine and associated System Assemblies.**

This module covers the units:

- Overvimew of engine and associated systems
- Remove and disassemble system assembly
- Replace/reassemble system assemblies
- Clean up work area and maintain equipment

Learning Objective of the Module

- Overview of engine and associated systems
- Removing and disassembling system assembly
- Replacing/reassembling system assemblies
- Clean up work area and maintain equipment

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the "LAP test" giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one: Overview of engine and associated systems

This unit is developed to provide you the necessary information regarding the following content coverage and topics:
• Overview of engine and associated systems • Types of accessory drives related Components • Types and application of gaskets and sealants • Parts registration/identification number • Service work activity plan • OHS and Hazard identification This unit 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: • Overviewing of engine and associated systems • Identify types of accessory drives related Components • Identify types and application of gaskets and sealants • Identify parts registration/identification number • Preparing service work activity plan • OHS and Hazard identification

1.1 Overview of engine and associated systems

An Engine is a mechanical machine used to convert the chemical energy of the fuel into heat energy and then to mechanical energy. It is usually called ***a Heat Engine.***

Basically there are two types of heat engines external and internal combustion engines.

a) In an external combustion engines combustion (burning of a fuel) is taking place outside of the Engine. **Eg**. Steam engines

b) In an internal combustion (IC) engines combustion is taking place within the engine itself. **Eg**. Spark Ignition (SI) engines

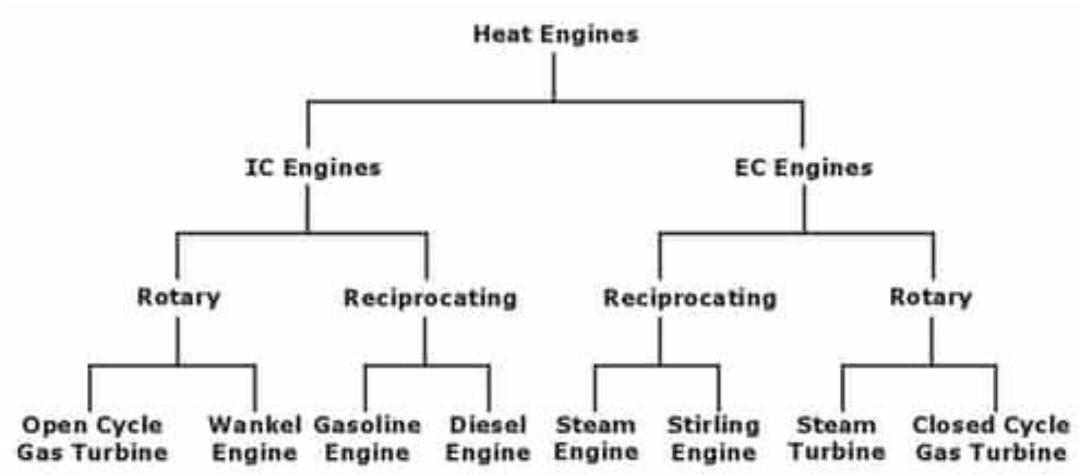


Figure 1-1 Engine classification

1.2 Engine mechanism and exterior parts

a) Crank gear mechanism: - which includes the crank shaft, connecting rod, piston and cylinder.

b) Valve gear mechanism: - which includes the camshaft, valve lifter, push rod, rocker arm and shaft, valve spring, intake and exhaust valves.

1.3 Engine systems

a. The starting system; - which includes the battery, start/ignition switch, starter motor.
b. The intake system: - which includes the air filter, carburetor, intake manifold.
c. The fuel system: - which includes the fuel tank, fuel line, fuel filter, fuel pump and carburetor.
d. The ignition system: - which includes the battery, start/ignition switch, ballast resistor, ignition coil, distributor, HT cable and spark plug.
e. The lubricating system: - which includes the oil pan, strainer, oil pump, oil line, oil filter.

f. The exhaust system: - which includes the exhaust manifold, exhaust pipe, catalytic converter, muffler, tail pipe.

g. The charging system; - which includes the battery, start/ignition switch, regulator, alternator.

h. The cooling system: - which include the radiator, lower hose, water pump, water jacket, thermostat, Upper hose, and cooling fan.

1.4 Types of accessory drives related Components

A. Water pumps

The burning of fuel in an internal combustion engine produces heat, which is sufficient to melt the metal of the cylinder. It is the function of the cooling system to prevent the engine overheating but it must also allow it to operate at a temperature high enough to assist in effective combustion.

If the engine operating temperature were allowed to go unchecked, it would burn and dry up the lubricating oil film, so that the pistons would seize in their cylinders and distortion would result from over-expansion of metals.

Figure 1-2 Water pumps

B. Alternators

In the charging system electronics devices such as diodes for rectification of current in alternator zanier diode and transistor for circuit opening and closing in transistorized regulators are use. In this unit, the construction and function of diodes and transistor, the purpose of the charging system, the component parts of alternators, the generating principles of alternator, the charging system service and repair are thoroughly discussed.

Figure 1-3 Alternators

C. AC compressors

The compressor is the power unit of the air-conditioning system that puts the refrigerant under high pressure before it pumps it into the condenser, where it changes from a gas to a liquid. A fully functioning compressor is necessary for the air-conditioning system to provide peak performance.

Figure 1-4 AC compressors

D. Power steering pumps

The power-steering unit is designed to reduce the amount of effort required to turn the steering wheel. It also reduces driver fatigue on long drives and makes it easier to steer the vehicle at slow road speeds, particularly during parking. Power steering can be broken down into two design arrangements: conventional and nonconventional or electronically controlled. In the conventional arrangement, hydraulic power is used to assist the driver.

Figure 1-5 Power steering pumps

In the nonconventional arrangement, an electric motor and electronic controls provide power assistance in steering. There are several power-steering systems in use on passenger cars and light-duty trucks. The most common ones are the integral-piston, and power assisted rack and pinion system.

E. Supercharger

A supercharger is an air compressor that increases the pressure or density of air supplied to an internal combustion engine. This gives each intake cycle of the engine more oxygen, letting it burn more fuel and do more work, thus increasing the power output.

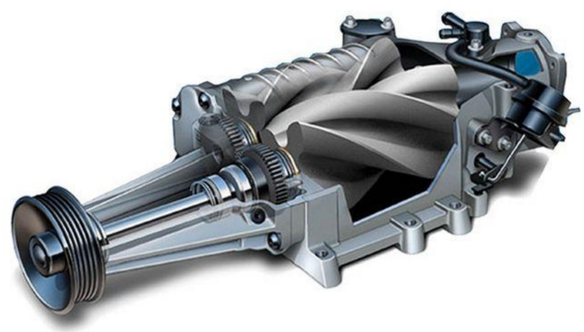


Figure 1-6 Supercharger

1.5 Types and application of gaskets and sealants

Gaskets seal a connection between two components or flanges that have flat surfaces, while seals are used between engine parts, pumps, and shafts that rotate. Gaskets are used wherever a union or flange is required to prevent leaking.

Gaskets are most commonly used as static seals. Gasket made of fiber materials, rubber, neoprene (synthetic rubber), cork, treated paper, or thin steel. When parts are fastened together, the gasket material fills small gaps, dents, or scratches in the mating surfaces.

Figure 1-7 Gaskets

Gasket Rules

1. Inspect for leaks before disassembly
2. Be careful not to damage mating surfaces while removing parts
3. Clean off old gaskets carefully
4. Wash and dry parts thoroughly
5. Use a sealer if specified
6. When assembling, start all bolts by hand
7. Tighten fasteners in steps
8. Use a crisscross tightening pattern
9. Do not over tighten fasteners
10. apply only the specified torque

Figure 1-9 Seals

Seals are used between engine parts, pumps, and shafts that rotate rather than those that are static. This type of seal is generally a molded or machined product. Seals tend to be flat and round, while gaskets are often cut into different shapes so that they fit the components. Most seals are made of an outer ring that is metal and nests over an inner surface that is often made of rubber. The inner circle is tilted just a bit, which creates a lip for the seal. The lip is designed as a second barrier against any drops that manage to get past the first edge of the seal. It is essential that seals be installed correctly because, if it's installed backward, you could end up with a leaky mess on your hands.

Type	Temperature range	Use	Resistant to	Characteristics
shellac	–65° to 350° F (–54° to 177° C)	general assembly: gaskets of paper, felt, cardboard, rubber, and metal	gasoline, kerosene, grease, water, oil, and antifreeze mixtures	dries slowly sets pliable alcohol soluble
hardening gasket sealant	–65° to 400° F (–54° to 205° C)	permanent assemblies: fittings, threaded connections, and for filling uneven surfaces	water, kerosene, steam, oil, grease, gasoline, alkali, salt solutions, mild acids, and antifreeze mixture	dries quickly sets hard alcohol soluble
nonhardening gasket sealant	–65° to 400° F (–54° to 205° C)	semipermanent assemblies: cover plates, flanges, threaded assemblies, hose connections, and metal-to-metal assemblies	water, kerosene, steam, oil, grease, gasoline, alkali, salt solutions, mild acids, and antifreeze solutions	dries slowly nonhardening alcohol soluble

Figure 1-8 Types of sealant

Common uses for seals include keeping leaks from occurring at the end of the shaft where it comes out of the cover and sealing hydraulic lines. This type of seal is generally a molded or machined product. Seals are often used in bearings, which is basically just a ball bearing surrounded by a rubber seal, which keeps it from leaking and sometimes reduces the amount of noise that occurs during operation.

1.6 Parts registration/identification number

A. VIN number

Before any service is done to a vehicle, it is important for you to know exactly what type of vehicle you are working on. The best way to do this is to refer to the vehicle's identification number (VIN). The VIN is given on a plate behind the lower corner of the driver's side of the windshield as well as other locations on the vehicle.

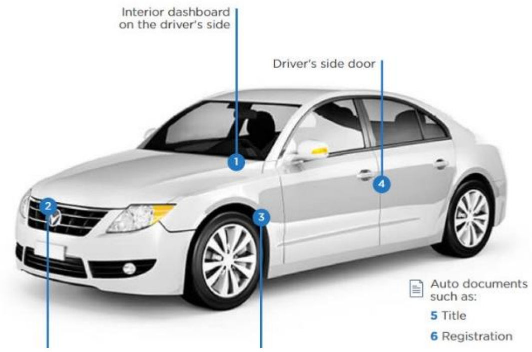


Figure 1-10 VIN location

The VIN is made up of seventeen characters and contains all pertinent information about the vehicle. The use of the seventeen numbers and letter code became mandatory beginning with 1981 vehicles and is used by all manufacturers of vehicles both domestic and foreign. Most new vehicles have a scan code below the VIN.

Each VIN number represents different data. The following information can be determined be reading the VIN number.

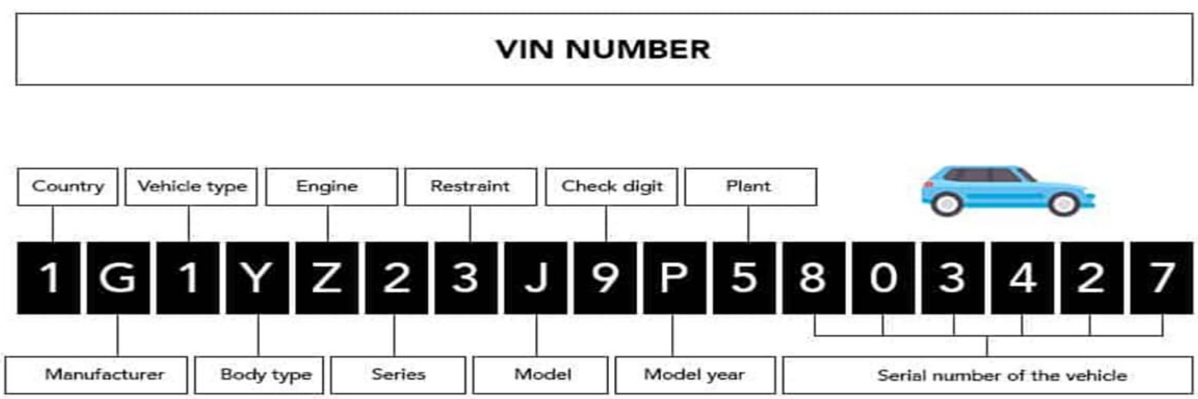


Figure 1-11 VIN representation

B. Engine Identification

By referring to the VIN, much information about the vehicle can be determined. Identification numbers are also found on the engine. Some manufacturers use tags or stickers attached at various places, such as the valve cover or oil pan. Blocks often have a serial number stamped into them. Service manuals typically give the location of the code for a particular engine. The engine code is generally found beside the serial number. The engine code will help you determine the correct specifications for that particular engine.

Engine ID Tags Many engines have ID tags or stickers attached to various places on the engine, such as the valve cover or oil pan. The tags include the displacement, assembly plant, model year, change level, engine code, and date of production. Service manuals normally note the location of these stickers or tags on a particular engine.

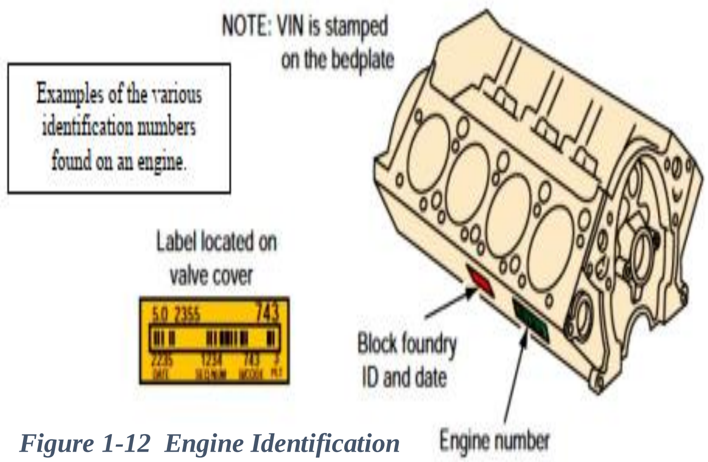


Figure 1-12 Engine Identification

1.7 Preparing service work activity plan

Specifications are included as part of the service manual. Specifications are technical data, numbers, clearances and measurements used to diagnose and adjust automobile components. Specifications can be referred to as specs. They are usually considered precise measurements under

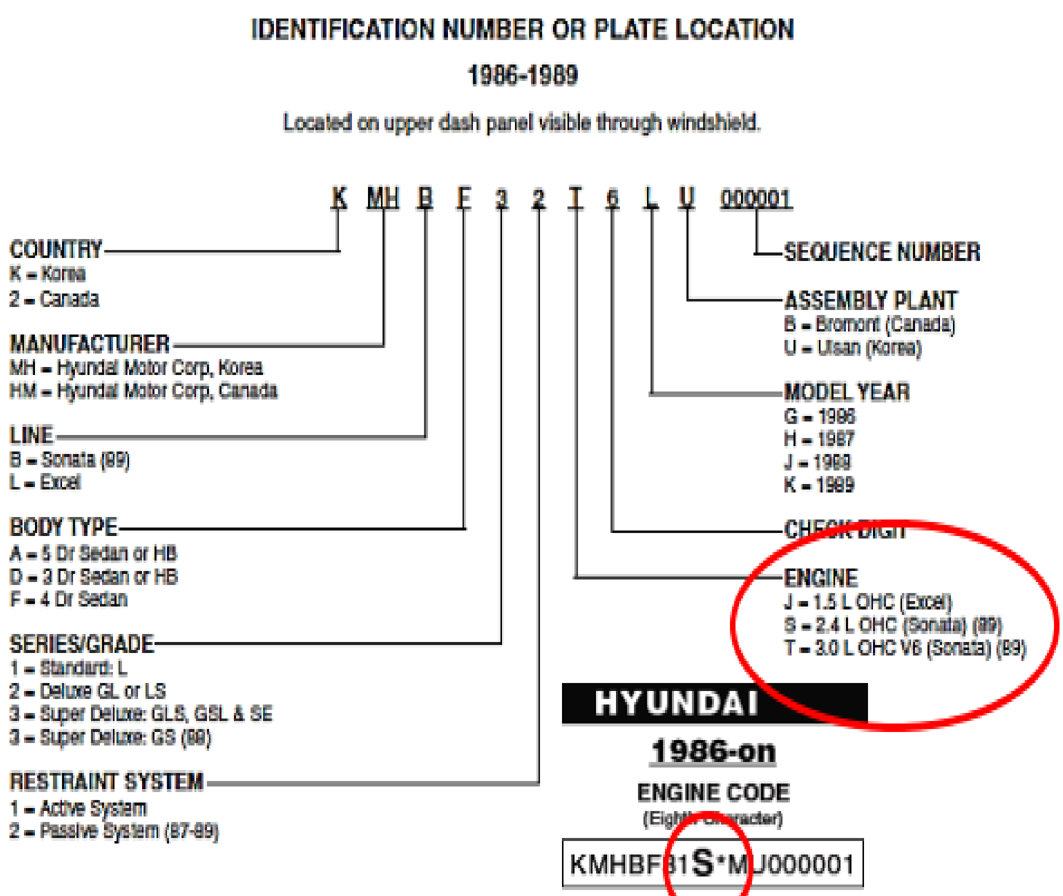


Figure 1-13 Engine ID number

standard conditions. Examples of specifications include valve clearances, spark plug gaps, and tire pressure, number of quarts of oil, ignition timing and size of engine.

A. Types of specifications

General Engine Specification– This specification identify the size and style of the engine. They include cubic inch displacement, engine codes, fuel system settings, bore and stroke, horsepower, torque, compression ratio, and normal oil pressure.

Tune-Up specifications – This specification helps identify adjustments necessary for tune-up on the vehicle. This includes spark plug gap, firing order, degrees of ignition timings, fuel system settings and fuel pump pressure.

Capacity Specifications –This specification includes identifying the capacity of different fluids on the vehicle. This includes cooling capacity, number of quarts of oil, fuel tank size, transmission transaxle capacity, and rear axle capacity.

Overhaul and Maintenance Specifications – This specification used to aid technician in servicing the vehicle. This include distributor advance at different speeds, valve seat angles, valve stem clearance, piston measurements, ring end gaps, bearing clearances, shaft end play and many more. This specification help the technician determine how much wear has occurred. The mechanic is then able to decide whether or not to replace the component in question. Usually maximum or minimum clearances are given for this purpose.

Operational Specification – This specification tell how the vehicle is to operate, what type of oil to use, and so on. Some of them are found in the owner's manual. Other specification includes tire inflation, type of gasoline to use, tire size and general information for the operator of the vehicle.

Torque Specification – It is important to torque each bolt or nut correctly when replacing or installing a component on the automobile. Torque specifications are used for this purpose. This torque specification should be used in place of any standard bolt and nut torque specification.

Owner's manual

An owner's manual or an operator's manual is a booklet that comes with a new car. This manual usually explains how to operate the automobile's control and accessories. In addition the owner's manual provides a great deal of technical information that can be useful to the technician.

In an owner's manual a vehicle maintenance procedure is provided so that the owner will know when to get needed service.

Aftermarket repair manual

An aftermarket repair manual is most often used by the technician at independent repair shops. This manual is called an aftermarket because it is published by independent publisher and not by the car manufacturer. Like the shop manual. This contains information on troubleshooting, specifications and step-by-step repair procedures. The main difference is that they cover many different car models and years instead of just one. Because they are covering more models and years, they typically cover topics in less detail.

1.8 Purpose of Periodic Maintenance

An automobile is constructed from a large number of parts, which can become worn down, weakened or corroded to lower the performance, depending on the conditions or the length of use. Constructed parts, which can be estimated that performance goes down, are needed to have a periodic maintenance, then adjust or replace to maintain the performance. By carrying out periodic maintenance, the following results can be achieved, ensuring the customer's trust and peace-of-mind:

1. Much larger problems with the vehicle that may occur later can be avoided.
2. The vehicle can be maintained in a state which is in adherence to legal regulations.
3. The life of the vehicle can be extended.
4. The customer can enjoy an economic and safe driving experience.

T, R, I, A, L stand for symbols of maintenance operation.

T=Tighten to specified torque

R=Replace or change

I=Inspect and correct or replace as necessary

A=Check and/or adjust as necessary

L=Lubricate

Service intervals

Service intervals are decided according to the distance traveled and the period elapsed since the previous service. For example, if the maintenance schedule for a particular part is stated as 40,000 km or 24 months, maintenance falls due at the point at which either of these conditions is met. The vehicle is therefore due for service after either: Driving 40,000 km/12 months ( ) after its previous service or driving 5,000km/24 months ( ) after its previous service. If the vehicle is being used under any of the following conditions, frequent maintenance will be necessary:

.

1.9 OHS and Hazard identification

OHS (occupational health and safety) is a cross disciplinary area concerned with protecting the safety, health and welfare of people engaged in work or employment. The goal of occupational health and safety (OHS) is:-

- ✓ To protect every working man against the dangerous of injury, sickness or death through safe healthful working condition.
- ✓ To protect co-workers, employers, customers, suppliers and other members of the public who are impacted by the work place environment.

The requirements of OHS are:-

- ✓ Safety
- ✓ Personal protective equipment/ need/
- ✓ First aid
- ✓ Fire extinguisher
- ✓ Hazardous materials

Self-Check 1

1) What are the Advantages supercharge
    a) A belt drives the supercharger
    b) The supercharger turns, compressing the air inside the housing and forcing it into the intake manifold
    c) An electromagnetic clutch is sometimes used to disengage the drive belt from the blower
    d) No “turbo lag”
2) ____________ is called an aftermarket because it is published by independent publisher and not by the car manufacturer?
    A) Part Catalog B. specification C. repair manual D. service manual
3) 3_______ called a shop manuals, are written by the automotive manufacturer for the technicians in their dealership.

    A. Manufacturer’s service manual B. specification C. repair manual D. structural manual

4) ______ Which one the purpose of to provide all the information necessary to describe all item accurately both physically and intellectually in order to distinguish it from every other items.

A. Part catalog B. specification C. repair manual D. structural manual

Unit Two: Remove and disassembled system assemblies

This unit to provide you the necessary information regarding the following content coverage and topics:
• Service and maintenance schedules and job order • Overview of service technique • Engine exterior assembly • Engine systems assembly 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: • Service and maintenance schedules and job order • Overviewing of service technique • Disassembling engine exterior assembly • Removing engine systems and assembly

2.1 Service and maintenance schedules and job order

Automobiles need maintenance from time to time. Like humans are required to maintain hygiene, similarly automobiles also need to be kept clean. Automobiles have to run on dirty roads and in a polluted environment. They run on uneven roads with potholes and other obstructions, and are therefore subjected to loads which damage them. Therefore, there is a need for regular maintenance and servicing of automobiles, which is usually done in auto workshops or auto service stations. In this Unit, you will understand the concept of vehicle maintenance and servicing.

As you may be aware, there is an increase in the number of vehicles, such as motorcycle, scooter, bus, car, jeep, tempo, truck, tanker, etc., running in the cities. Every new vehicle comes with a vehicle maintenance manual. The owner of the vehicle is expected to read and use this manual, as it mentions vehicle maintenance

A. Vehicle Maintenance and Servicing

Tips during driving. It has been noticed that after getting a car or vehicle, the owners do not care much about a regular car or vehicle maintenance. Even if the owners regularly service their vehicle, the vehicle maintenance tips given in the vehicle maintenance manual increases the longevity or life of the vehicle to a great extent. Vehicle maintenance and servicing is carried out when the vehicle completes certain kilometers on its normal running or when the vehicle does not give proper performance. It is suggested that the vehicle owners carry out regular and periodical checks on their vehicle, some of which are mentioned below.

B. Daily Inspection (DI)

It is the responsibility of a driver or owner of a vehicle to carry out the following inspection and checks daily, before starting the engine, to avoid any type of breakdown on the road.

a) Check tire pressure in all the tires visually or by hitting the tire wall with the help of a stone and judge the sound
b) Check the radiator’s coolant level
c) Check the fan belts for looseness
d) Check the level of engine oil
e) Check the windscreen, rear-view mirror and rear window glass for their cleanliness

C. Maintenance Check-up

When one plans a long distance travel, it is necessary to carry out a routine check-up. One should read the vehicle maintenance manual for clarity. Some important check-ups are done for better maintenance

- ✓ Topping of oil level
- ✓ Proper tension of belt
- ✓ Battery for cleanliness and level of electrolyte
- ✓ Brakes
- ✓ Air conditioning
- ✓ Topping up of coolant, if required, in the coolant reservoir
- ✓ Checking the serviceability of cooling system hoses
- ✓ Proper tire inflation pressure

2.2 Overview of service techniques

A. Visual check

A visual inspection report form is completed by quality assurance inspectors to document pass/fail decisions on visually inspected products based on set defect criteria. Use this checklist to effectively indicate product ID and location, capture photo evidence of products and/or defects, determine pass/fail decisions based on a reference image, identify visual defects based on defect criteria, and complete the visual inspection with a digital signature.

B. Sound/aural checks

Diagnosing engine noise is often one of the most difficult tasks you can deal with. Most of the noises that come from the engine can be described by such words as:

- ✓ **Piston Ring Noise**

  Sounds like: Clicking noise during acceleration.

  Common causes: Low ring tension, broken rings, or worn cylinder walls

  Try troubleshooting each cylinder by removing the spark plugs and adding a spoonful of engine oil to each cylinder. Now crank the engine quite a few revolutions to allow the oil to go down past the rings. Install the spark plugs and start the motor. If the noise is lessened then the rings are likely the source of the problem.

✓ **Piston Slap**

Sounds like: Continuous muffled, hollow sound.

Common causes: Excessive piston-to-wall clearance, worn cylinders or inadequate oil.

A continued piston slap noise indicates that the engine needs service. Still, if the sound is only heard when the engine is cold, it is probably not a serious issue.

✓ **Crankshaft Knock**

Sounds like: Dull, heavy, metallic knock under load.

Common causes: Worn bearings; main, rod, or thrust.

Damaged or worn main bearing noise is loudest under heavy load. Check your oil dipstick for any metal reflections. Metal shavings in the oil is one of the first indications of your main bearing material sloughing off. Replace any worn bearings with new ones.

✓ **Valve train Noise**

Sounds like: Regular clicking noise at half-speed.

Common causes: Excessive valve clearance or defective valve lifter.

You can check your clearances by inserting a thickness gauge between the lifter or rocker arm and the valve stem. If the noise is reduced, then the cause is excessive clearance and you will want to make the correct adjustments. If the noise persists, then it is most likely rough cams or worn lifter faces. You might also want to look for loosley moving lifters in their bores and weak valve springs.

✓ **Detonation**

Sounds like: High-pitched metallic pinging noise.

Common causes: Improper timing, lean air/fuel ratio, or improper octane.

You can prevent detonation by increasing the octane level of your fuel, reducing manifold pressure, enriching the air/fuel mixture, or obstructing the ignition timing. Detonation can often be a common phenomenon in forced induction applications. For some operations, you can consider an aftermarket water injection system.

✓ **Connecting Rod Noise**

Sounds like: Light knocking or pounding sound.

Common causes: Misaligned rod, inadequate oil, or worn bearing or crankpin.

A cylinder-balance test can single out the faulty connecting rod. With the engine running, this test essentially shorts out the spark plugs one cylinder at a time. Soon, you can narrow down the bad connecting rod as the sound will be lessened when its base cylinder is no longer delivering power.

✓ **Piston Pin Noise**

Sounds like: Metallic, double knock at idle.

Common causes: Worn bushing, worn or loose piston pin, or inadequate oil.

Conduct a cylinder-balance test like described above to discover the distressed components.

2.3 Adjustment of system/components

A. Valve Adjustment

To check the clearance of any valve accurately, hot or cold, you must rotate the engine so that the valve is fully closed and the heel, or base circle, of the came lobe is on the tappet. This provides maximum clearance. Insert a flat feeler gauge of the specified thickness between the valve stem and the rocker arm or cam follower.

Figure 2-1 Valve Adjustment

Obviously the clearances should be checked when they are at their widest which ,with most overhead camshaft arrangements is no problem for once the cover has been removed the actual cams can be seen the gap is at its widest the lobe of the cam is pointing directly away from the valve or rocker. In overhead valve layouts it’s rather more difficult because the camshaft cannot be seen with these or any or similar layout there is some method of setting the gap at its widest.

B. Valve identification

Usually the specified clearance at the exhaust valve will be greater than that of the inlet, which means that it is important to be able to differentiate one the other.

One way of doing this is to note the location of the valve in relationship to the manifold braches at the cylinder head. Example if the exhaust manifold branches terminate at the end of the cylinder head, then the first & the last valves are both exhaust.

The valve layout of a typical four cylinder engine would be E,I,I E,E,I,I,E. Where E =Exhaust &I= Intake.

A further method of identifying which valve is which is to turn the engine over in its normal direction of rotation and watch the valves (or rockers), at each cylinder, the exhaust valve will open &close, will be immediately followed by the inlet. The engine can then be turned through nearly a complete revolution before the exhaust will open.

Excessive valve clearance would result in:

- Presence of a regular taking sound: the noise can become more of a general clatter emanating from the top of the engine, if more than one valve clearance is excessive.
- The valve is not fully open: The valve opens too late & closes too early.
- The valve is returned to its seat much faster than it would normally do. In severe cases this can result in the head of the valve breaking off causing extensive engine damage.
- With some arrangements, an indentation may being created in the rocker (tinge pad).
- When the valve clearance increases it might cause engine noise, increased emission, or decreased engine performance.

2.4 Disassembling engine exterior assembly

- Detach the injection pump and high-pressure lines.
- The air compressor should be removed.
- If the engine have oil cooler, remove the oil cooler.
- Remove oil and fuel filters.
- Remove the alternators and its driving belts.
- Remove the starter motor and its wire harness
- Remove steering gear fluid pump.
- Detach the water pump from its mounting part.
- Remove the intake manifold and exhaust manifold with the turbo charger.
- Remove all injectors and glow plugs
- Engine temperature and oil pressure senior should be removed.

2.5 Removing and Disassemble engine systems

2.5.1 Cooling system

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.

A. Types of cooling systems

a) **Air-cooled**

Air-cooled: 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

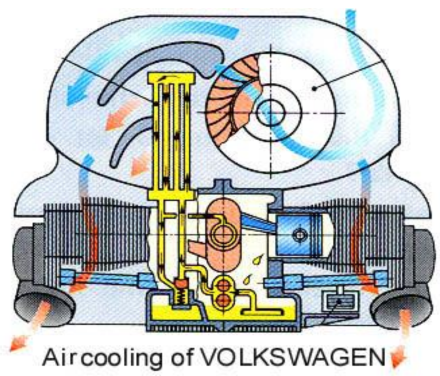


Figure 2-2 Air-cooled engine

b) Liquid-cooled

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.

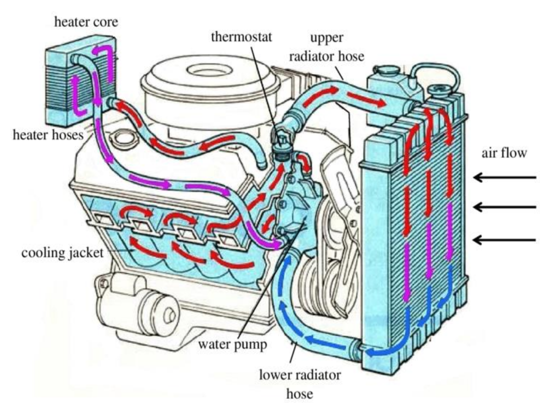


Figure 2-3 Liquid-cooled engine

B. Cooling system problem

a) Engine overheating

The most common cooling system problem is overheating. There are many reasons for this. Diagnosis of this condition involves many steps, simply because many things can cause this problem. Basically, overheating can be caused by anything that decreases the cooling system's ability to absorb, transport, and dissipate heat: The first step is to determine whether the engine is indeed overheating.

An overheating concern normally begins with high readings on the vehicle's temperature gauge or the illumination of the temperature warning lamp. These can be caused by a cooling system problem or a faulty temperature sensor, although when the engine is greatly overheating, it is obvious by the steam emitted by the system or by smell. The best way to check the accuracy of the temperature indicators is to measure the temperature of the coolant. If the indicators seem to be wrong, troubleshoot and repair the electrical circuit. Then recheck the system's temperature.

Condition	**Cause**
Overheats in heavy traffic or after idling fora long time	■ Low coolant level ■ Faulty radiator cap ■ Faulty thermostat ■ Cooling fan is not turning on ■ Restricted airflow through the radiator ■ Leaking head gasket ■ Restricted exhaust ■ Water pump impeller is corroded
Overheats when driving at speed, or after repeated heavy acceleration	■ Radiator and/or block are internally clogged with rust, scale, silt, or gel ■ Restricted airflow through the radiator ■ Faulty radiator cap ■ Faulty thermostat ■ Radiator fins are corroded and falling off ■ Water pump impeller is corroded ■ Dragging brakes
Overheats any time or Erratically	■ Low coolant level ■ Faulty radiator cap ■ Faulty thermostat ■ Temperature sender or related electrical problem ■ Cooling fan is not turning on

Overheats shortly after the engine is started	■ Temperature sender or related electrical problem
Seems slightly too hot all of the time; gauge nears the red zone at times	■ Radiator and/or block are internally clogged with rust, scale, silt, or gel ■ Restricted airflow through the radiator ■ Faulty radiator cap ■ Faulty thermostat ■ Radiator fins are corroded and falling off ■ Collapsed lower radiator hose ■ Cooling fan is not turning on
Bubbles in the coolant expansion tank	■ Faulty radiator cap ■ Failed head gasket
Air in the radiator but the expansion tank is full	■ Coolant leak ■ Faulty radiator cap ■ Air in the system ■ Faulty seal between the radiator cap and expansion tank ■ Failed head gasket

b) Check for external leaks

i. External leaks

Usual areas of leakage are water manifolds, radiator seams, water pumps, freeze plugs and all those connections. The condition of radiator hoses should be carefully scrutinized for possible deterioration from age and/or wear from rubbing against accessory brackets, etc. Be aware that in many cases radiator hoses wear from the inside out, so outside appearance can be deceiving.

- Cracked cylinder block
- Faulty radiator cap
- Dented radiator inlet of outlet tube
- Radiator leak
- Cracked or porous water pump housing
- Water core leak
- Loose core hole plug in cylinder block
- Cracked thermostat housing

ii. Internal leaks

Pull the oil dipstick and check for evidence of coolant. It will show up as minute droplets or sludge and should be easy to spot. This could indicate a cracked head, block or blown head gasket.

C. Cooling system inspection and test

a) Inspecting Cooling System for Leaks

1. Fill the radiator and engine with coolant, and attach a radiator cap tester to the water outlet.
2. Warm up the engine.
3. Pump it to 118 kPa (1.2 kgf/cm2, 17.1 psi), and check that the pressure does not drop. If the pressure drops, check the hoses, radiator or water pump for leaks. If no external leaks are found, check the heater core, cylinder block and head.

b) Temperature Test

A temperature test can be performed with an infrared temperature sensor, thermometer, or temperature probe. The latter may be a feature of a digital multi-meters (DMM). A temperature test allows for monitoring temperature change through the cooling system. When a cold engine is started, the opening temperature of the thermostat can be observed as the engine warms.

c) Radiator Checks

Cold spots on the radiator indicate internal restrictions. In most cases, this requires removal of the radiator so it can be deeply flushed or replaced. Normal cooling system flushing will normally not remove the restrictions. The restrictions are typically caused by internal corrosion or a build-up of scale and lime.

d) Checking Hoses

Carefully check all cooling hoses for leakage, swelling, and chafing. Also replace any hose that feels mushy or extremely brittle when squeezed firmly. When a hose becomes soft, it is deteriorating and should be replaced before more serious problems result. Hard hoses will resist flexing and may crack rather than bend and should be replaced.

e) Checking Fans and Fan Clutches

To confirm the diagnosis, start with this simple test: Spin the fan as hard as you can on an engine that has not been started that day. If the fan rotates more than five times, you can bet the clutch is bad. You should feel some resistance and the fan may spin up to three times, depending on the ambient temperature.

f) Thermostat

If the thermostat is stuck open or closed, you may think the best option is to lose it and take it to a mechanic for diagnosis. I have good news. I will show you how to check for bad thermostats in a car without removing them. One common cause of overheating in a car is a faulty thermostat. If you suspect this component, inspect it to see if it is the culprit. Here's how to check a car thermostat without removing it.

2.5.2 Lubrication system

The lubricating system supplies lubricating oil to all moving parts in the engine. It also control of friction and wear by the introduction of a friction–reducing film between moving surfaces in contact.

Lubrication as a substance lubricated material freely moving, reciprocating, back and forth movement between two hard body materials. System a way set of things working together as a mechanism

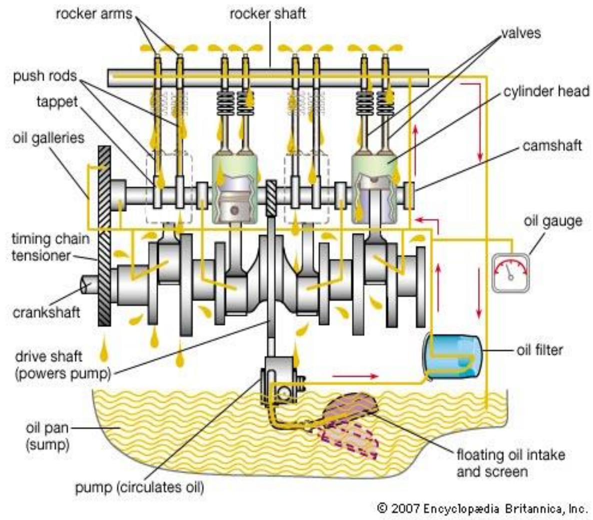


Figure 2-4 Lubrication system

A. Purpose of Lubricants

1. *Minimize Friction* – the oil must form a film between highly loaded moving parts.
2. *Prevent Wear* – the must protect highly loaded parts which can wear out when the fluid film is very thin (boundary lubrication).
3. *Act as a coolant* – the oil must remove heat generated both inside and outside the equipment.
4. *Act as a Hydraulic Medium* – the oil doesn't have this job in all applications, but it is not uncommon for the lubricating oil to be part of the hydraulic system.
5. *Prevent Corrosion* – The oil must protect precision parts made of various metals, which are vulnerable to rust and corrosion.
6. *Prevent formation of deposits* – lubricants are designed to resist formation of deposits (like sludge and varnish), which can accumulate in the lubricating system and interfere with the oil's ability to lubricate.
7. *Carry away contaminants* – the oil often wear in the process of carrying contaminants to the filter. Contamination is the major reason oils must be changed. Contaminants can come from both internal and external sources.

B. Properties of Lubricating Oil

1. ***Proper Viscosity*** – means to measure the oil's resistance to flow. A low-viscosity oil is thin and flows easily. A high-viscosity oil is thicker. It flows more slowly.
2. ***Viscosity Index*** – this is a measure of how much the viscosity of an oil changes with temperature.
3. ***Viscosity Numbers*** – lubricating oils either in single or multi-viscosity oils are rated according to its numbers. **SAE 30** or **SAE 40** are examples of a single-viscosity oil and **SAE20W50** is also an example of a multi-viscosity oil. The letter **W** indicated in multi-viscosity oil stands for ***Winter Grade*** and the word **SAE** means ***Society of Automotive Engineers.***
4. ***Resistance to Carbon Formation and Oil Oxidation*** – when oil is refine, chemicals are added to fight carbon formation and oxidation. These can occur at the high temperatures inside the engine.
5. ***Corrosion and rust Inhibitors –*** these are additives that are put in the oil to help fight corrosion and rust in the engine.
6. ***Foaming Resistance*** – the churning action of the crankshaft causes the oil to foam or aerate thus reduces the lubricating effectiveness of the oil. As a result, an additive is mix to prevent the oil to foam.
7. ***Detergent-Dispersant*** – These additives are similar in action to soap. They loosen and detach particles of carbon and grit from engine parts.
8. ***Extreme-pressure Resistance -*** this is another additives put into the oil to improve the resistance of the oil film to penetration.
9. ***Energy-Conserving Oil*** – this is a property of an oil which reduces fuel consumption when compared to engine operation.
10. ***Synthetic Oil*** – these oils are made by chemical processes and do not necessarily come from petroleum. This is a property of an oil which tolerates heat better than other oils while producing less sludge and carbon deposits.

C. Types of Lubricating System

1. **Splash Type** – it refers to the system in which the oil is being splashed from the oil pan into the lower part of the crankcase. Usually, the connecting rod has a dipper that dips into the crankcase oil each time the piston reaches BDC. Likewise, usually used in a smaller like a single cylinder engine.

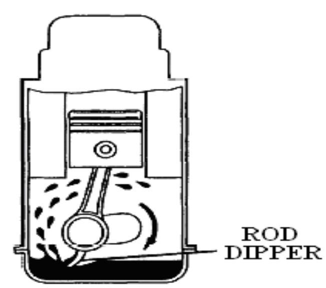


Figure 2-5 Splash Type

2. **Pressure Feed Type** – this type of lubricating system connotes that the engine parts are lubricated by oil fed under pressure from the oil pump.

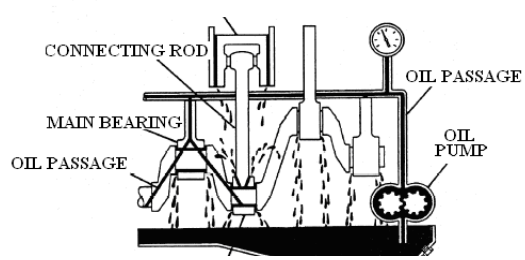


Figure 2-6 ***Pressure Feed Type***

D. Component Parts of the Lubricating System

1.) **Crankcase / oil pan** – it is an iron or aluminum casting enclosing the crankshaft; it is usually considered as the storage of oil in the engine.

2.) **Oil Pump** – it refers to a pump, which circulates lubricating oil from the engine's sump through the lubrication system. Likewise, an oil pump has of three kinds, to wit:

a) Rotary pump: the rotary pump has an inner rotor with lobes that match similar shaped depressions in the outer rotor. The inner rotor is off center from the outer rotor. As the oil pump shaft turns, the inner rotor causes the outer rotor to spin. The eccentric action of the two rotors forms pockets that change size. A large pocket is formed on the inlet side of the pump. As the rotors turn, the oil-filled pocket becomes smaller, as it nears the outlet of the pump.

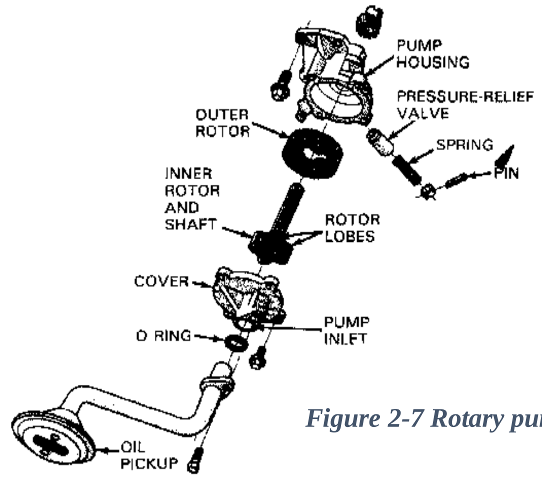


Figure 2-7 Rotary pump

b) The gear pump consists of two pump gears mounted within a close-fitting housing. A shaft, usually turned by the distributor, crankshaft, or accessory shaft, rotates one of the pump gears. The gear turns the other pump gear that is supported on a short shaft inside the pump housing.

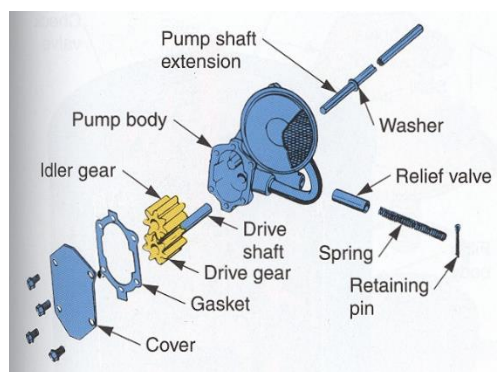


Figure 2-8 Gear type pump

c) The crescent pump

The crescent pump has external toothed gear meshed with an internal toothed gear. Some of the gears teethes are in mesh, the others are separated by a crescent shaped part of the pump housing. The suction and the discharge cavities are also separated by a crescent - shaped body. The pump is mounted on the front of the cylinder block so that the pump is driven directly from the crankshaft.

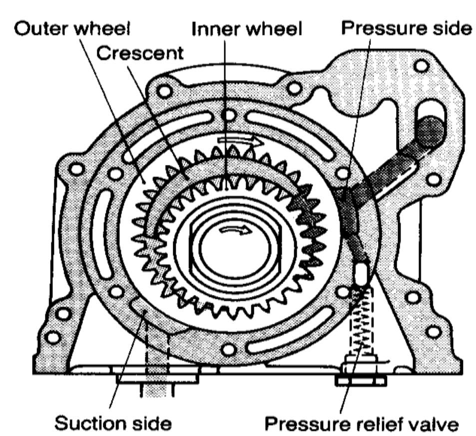


Figure 2-9 Crescent pump

3.) Oil Pickup and Strainer

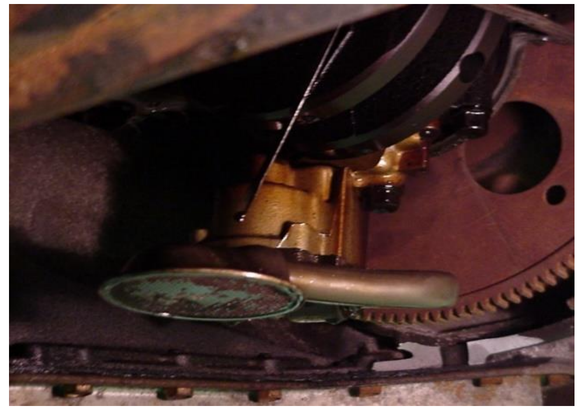


Figure 2-10 Oil Pickup and Strainer

The oil pickup is a tube that extends from the oil pump to the bottom of the oil pan. One end of the pickup tube bolts or screws into the oil pump or to the engine block. The other end holds the strainer. The strainer has a mesh screen suitable for straining large particles from the oil and yet passes a sufficient quantity of oil to the inlet side of the oil pump.

4.) Oil Filter

The oil filter removes most of the impurities that have been picked up by the oil, as it circulates through the engine. Designed to be replaced readily, the filter is mounted in an accessible location outside the engine.

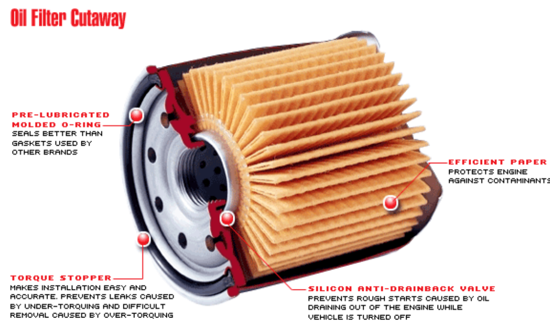


Figure 2-11 Oil Filter

5.) Oil Galleries

Oil galleries are small passages through the cylinder block and head for lubricating oil. They are cast or machined passages that allow oil to flow to the engine bearing and other moving parts.

The main oil galleries are large passages through the center of the block. They feed oil to the crankshaft bearings, camshaft bearings, and lifters. The main oil galleries also feed oil to smaller passage running up to the cylinder heads.

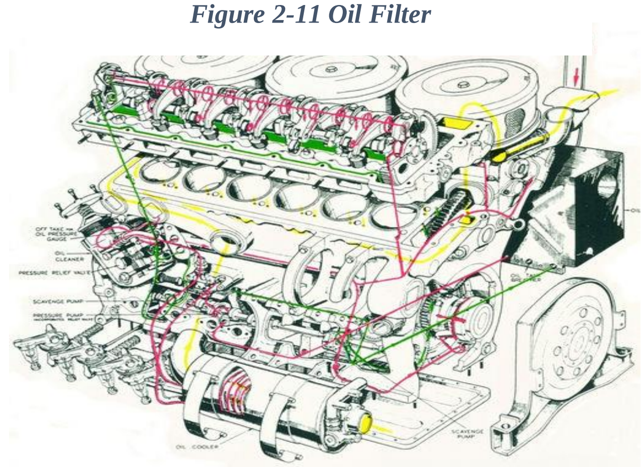


Figure 2-12 Oil Galleries

6.) Oil Pressure Warning Light

The oil pressure warning light is used in place of a gauge on many vehicles. The warning light, although not as accurate, is valuable because of its high visibility in the event of a low oil pressure condition.

Because the engine can fail or be damaged in less than a minute of operation without oil pressure, the warning light is used as a backup for a gauge to attract instant attention to a malfunction.

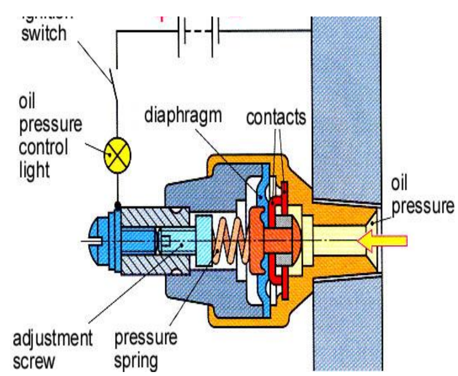


Figure 2-13 Oil Pressure Warning Light

7.) Oil cooler

Oil cooler is a heat exchanger which is either air cooled type or liquid cooled type. In air-cooled oil cooler, oil flow through heat exchanger tubes and coolant (air) passing over the tubes where as in liquid cooled cooler, both oil and coolant (water), the two being separated by tubes or baffles, flow through heat exchanger.

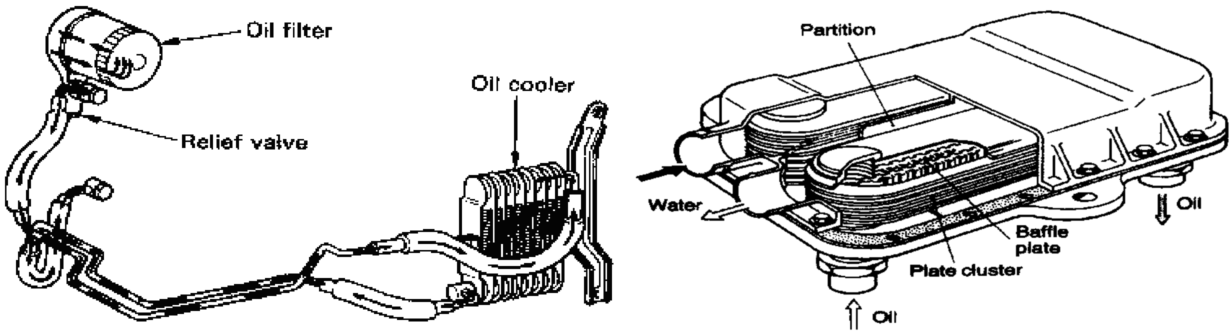


Figure 2-14 Oil cooler

E. Lubricating system problem diagnosis

To troubleshoot an engine lubricating system, begin by gathering information on the problem. Ask the operator questions. Analyze the symptoms using your understanding of system operation. You should arrive at a logical deduction about the cause of the problem.

The four problems most often occur in the lubrication system are as follows:

1. High oil consumption (oil must be added frequently)
2. Low oil pressure (gauge reads low, indicator light glows, or abnormal engine noises)
3. High oil pressure (gauge reads high, oil filter swelled)
4. Defective indicator or gauge circuit (inaccurate operation or readings)

When diagnosing these troubles, make a visual inspection of the engine for obvious problems. Check for oil leakage, disconnected sending unit wire, low oil level, damaged oil pan, or other troubles that relate to the symptoms.

a) High Oil Consumption

If the operator must add oil frequently to the engine, this is a symptom of high oil consumption. External oil leakage out of the engine or internal leakage of oil into the combustion chambers causes high oil consumption. A description of each of these problems is as follows:

- ✓ **External oil leakage**—detected as darkened oil wet areas on or around the engine. Oil may also be found in small puddles under the vehicle. Leaking gaskets or seals are usually the source of external engine oil leakage.

- ✓ **Internal oil leakage**—shows up as blue smoke exiting the exhaust system of the vehicle. For example, if the engine piston rings and cylinders are badly worn, oil can enter the combustion chambers and will be burned during combustion

b) Low Oil Pressure

Low oil pressure is indicated when the oil indicator light glows, oil gauge reads low, or when the engine lifters or bearings rattle. The most common causes of low oil pressure are as follows:

1. Low oil level (oil not high enough in pan to cover oil pickup)
2. Worn connecting rod or main bearings (pump cannot provide enough oil volume)
3. Thin or diluted oil (low viscosity or fuel in the oil)
4. Weak or broken pressure relief valve spring (valve opening too easily)
5. Cracked or loose pump pickup tube (air being pulled into the oil pump)
6. Worn oil pump (excess clearance between rotor or gears and housing)
7. Clogged oil pickup screen (reduce amount of oil entering pump)

A low oil level is a common cause of low oil pressure. Always check the oil level first when troubleshooting a low oil pressure problem.

c) High Oil Pressure

High oil pressure is seldom a problem. When it occurs, the oil pressure gauge will read high. The most frequent causes of high oil pressure are as follows:

1. Pressure relief valve struck (not opening at specified pressure)
2. High relief valve spring tension (strong spring or spring has been improperly shimmed)
3. High oil viscosity (excessively thick oil or use of oil additive that increases viscosity)
4. Restricted oil gallery (defective block casting or debris in oil passage)

d) Indicator or Gauge Problems

A bad oil pressure indicator or gauge may scare the operator into believing there are major problems. The indicator light may stay on or flicker, pointing to a low oil pressure problem. The gauge may read low or high, also indicating a lubrication system problem.

Inspect the indicator or gauge circuit for problems. The wire going to the sending unit may have fallen off. The sending unit wire may also be shorted to ground (light stays on or gauge always reads high). To check the action of the indicator or gauge, remove the wire from the sending unit. Touch it on a metal part of the engine. This should make the indicator light glow or the oil pressure gauge read maximum. If it does, the sending unit may be defective. If it does not, then the circuit, indicator, or gauge may be faulty.

2.5.3 Exhaust Gas System

When the combustion ends in each cylinder, the exhaust gas must be collected, cleaned, quieted, and then discharged into the air. This is the job of the exhaust system. It performs these tasks while carrying the exhaust gases from the cylinders to the atmosphere. This system includes the exhaust manifold, exhaust pipe, catalytic converter, muffler or silencer, resonator (on some cars), and tail pipe. The exhaust system has also flexible mountings that allow for engine movement and also prevent exhaust vibration from being transmitted to the body. They also allow thermal expansion of the system.

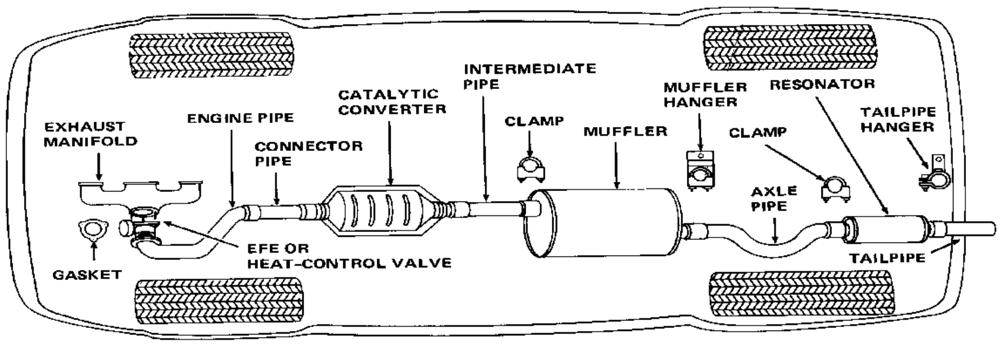


Figure 2-15 Exhaust Gas System

A. Exhaust system component

a) Exhaust Manifold

The exhaust manifold is made of cast iron and is bolted over the exhaust ports of the engine, usually alongside the intake manifold pipe. It provides heat to the intake manifold. This heat further vaporizes the fuel in the intake manifold.

Heat Control valve (or) Heat-Riser Valve

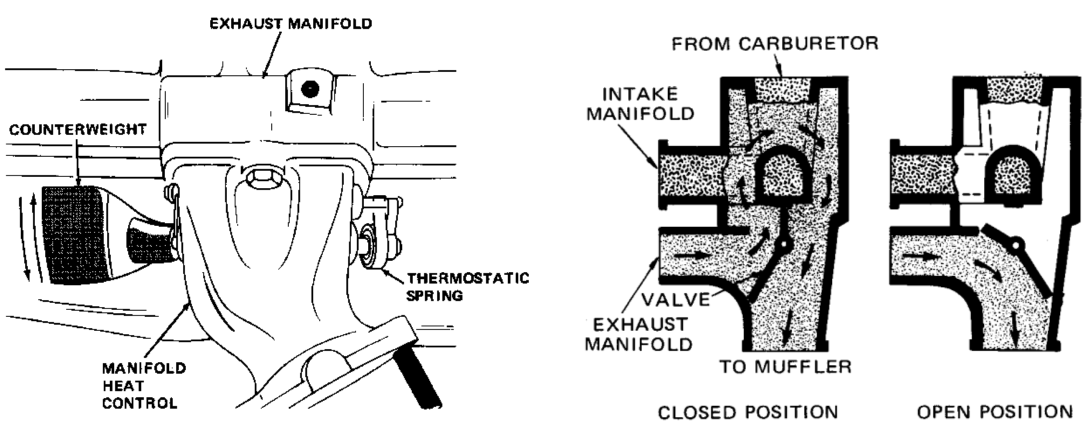


Figure 2-16 Heat Control valve (or) Heat-Riser Valve

During cold-engine operation, the gasoline must be vaporized before entering the cylinders. If the fuel is not properly vaporized, drops of gasoline will enter the cylinders. They will wash down the cylinder walls and remove the oil. This causes the walls, pistons, and piston rings to wear quickly. The heat control valve helps to vaporize the cold gasoline when the engine is cold.

Engines with a heat control valve warm a section of the intake manifold by allowing some of the exhaust gases through it. Placing a butterfly valve between the exhaust manifold and the exhaust pipe does this. Opening and closing of the valve is controlled by a thermostatic spring or by a vacuum motor. When the valve is operated by a vacuum motor, the system is called an Early Fuel Evaporation (EFE) system.

b) Exhaust Pipe

The exhaust pipe is a long pipe leading from the exhaust manifold to the muffler.

c) Catalytic converter

It is discussed under exhaust gas treatment.

d) Muffler

The exhaust gas emerges in a pulsating flow and therefore causes marked vibration in the exhaust pipes and mufflers (silencers). The muffler, located between the catalytic converter and the resonator or tail pipe, contains perforated pipes, baffles, and resonance chambers. Its purpose is to reduce the pressure pulses and to quiet or muffle the noise of the exhaust. Without a muffler, the exhaust gas pulsations would roar very loudly.

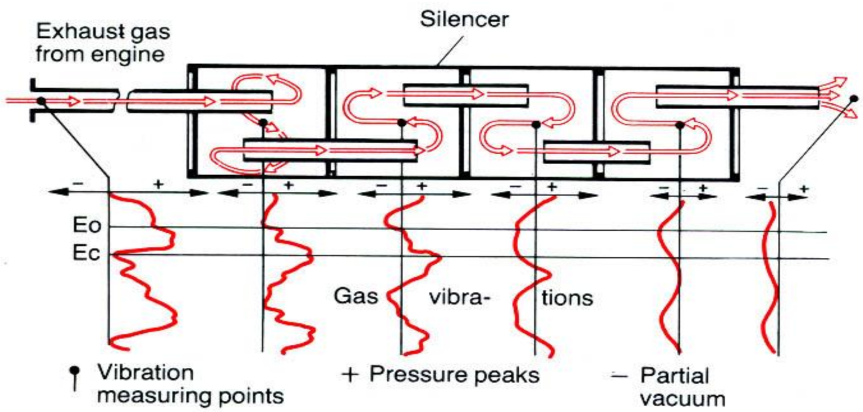


Figure 2-17 Muffler silencing operation

***e)* Resonator**

It is used to further muffle the noise of the exhaust gases. It is also called secondary muffler.

f) Tail Pipe

The tail pipe is a pipe that carries the exhaust gases from the muffler to the rear of the vehicle. This pipe may be a separate unit or an integral part of the muffler when the muffler is located near the rear of the vehicle.

All the elements in the exhaust system are very carefully matched together and must therefore not be altered individually. There is a possibility of the vehicles official documents being rendered invalid if the exhaust system is modified.

B. Treating the exhaust gas

Treating the exhaust gas means that some 'cleaning' of the exhaust gas occurs. It takes place after the exhaust gas leaves the engine cylinders and before it exits the tail pipe and enters the atmosphere. This reduces the amount of HC, CO and NOx content in the exhaust gas. The exhaust gas is treated in two different ways. One is by injecting the fresh air into the exhaust system. The other is by sending the exhaust gas through a catalytic converter.

1. Air-Injection (AI) & Air-Suction (AS) Systems

In this method, fresh air is supplied to the exhaust manifold by an air injection pump. So that it provides additional oxygen to burn HC and CO coming out of the cylinders.

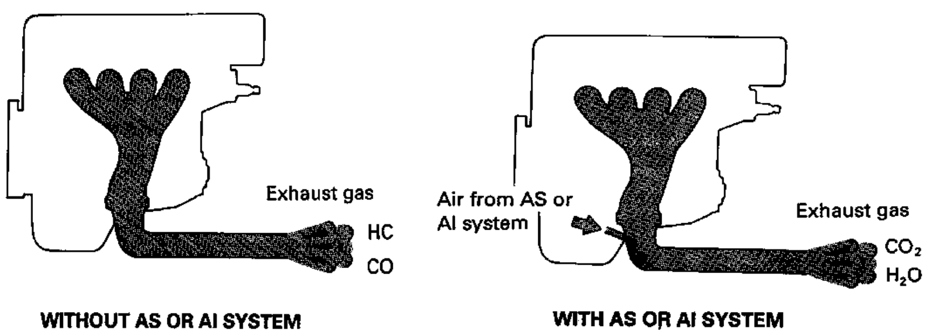


Figure 2-18 Air-Injection (AI) & Air-Suction (AS) System

2. Air-Aspirator (or) Air-Suction System

Some engines equipped with a catalytic converter use an air-aspirator system to deliver fresh air to the exhaust system. An air-aspirated valve is located in the tube between the air cleaner and the exhaust manifold or catalytic converter.

The aspirator valve opened and closed by the pressure in the exhaust system. The slight vacuum in the exhaust manifolds at idle and slow running causes the value to open, admitting air from the air cleaner to the exhaust system. The oxygen in the air helps to burn any HC or CO in the exhaust gas.

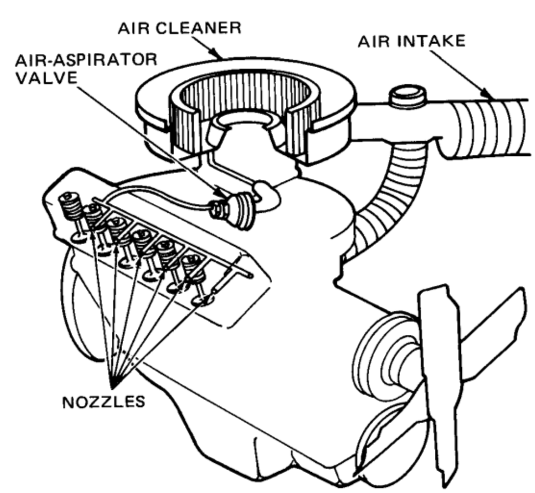


Figure 2-19 Air-Aspirator (or) Air-Suction System

3. Catalytic Converter

Catalytic converters provide another way to treat the exhaust gas. These devices located in the exhaust system, convert harmful gases into harmless gases. Inside the catalytic converter, the exhaust gases Passover a catalyst. A catalyst is a material that causes a chemical reaction. In effect, the catalyst encourages chemicals to react with each other. The metals such as platinum and palladium are act as oxidizing catalysts and rhodium as reducing catalysts.

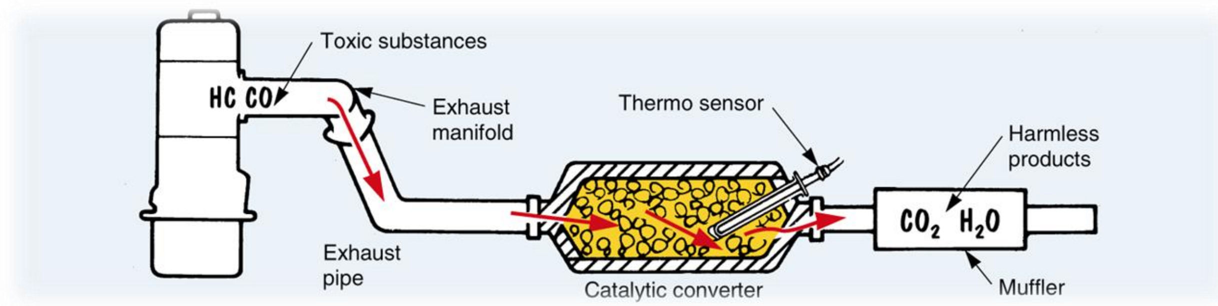


Figure 2-20 Catalytic Converter

There are three general categories of catalytic converters. *These are oxidizing, reducing, and three way*. The ***oxidizing converter*** handles HC and CO, using platinum or palladium as the catalysts. The ***reducing converter*** handles NOx using metal rhodium. It splits oxygen from the nitrogen. The NOx becomes harmless nitrogen (N2) and oxygen (O).

A dual bed catalytic converter has two pellet beds, one over the other. An air chamber separates the two. The upper bed contains pellets coated with a three-way catalyst. This catalyst mainly reduces NOx to nitrogen and oxygen, but it also oxidizes HC and CO.

The lower bed serves as a two-way catalyst. It further oxidizes the remaining HC and CO. When the engine warms up, secondary air from the air pump feeds into the air chamber separating the beds. The air helps the oxidizing catalyst convert the HC and CO into carbon dioxide and water. A similar action takes place in the three-way honeycomb catalytic converter.

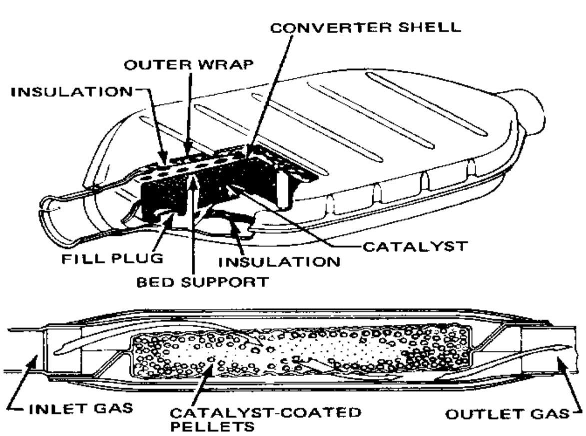


Figure 2-21 Two way catalytic convertor

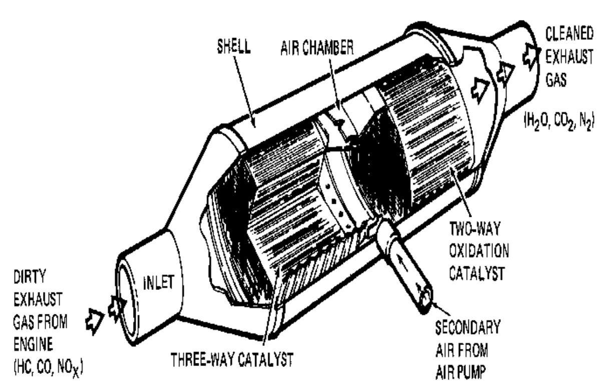


Figure 2-22 Three way catalytic converter

C. Exhaust System Service

Exhaust system components are subject to physical and chemical damage. Any physical damage to an exhaust system part that causes a partially restricted or blocked exhaust system usually results in loss of power or backfire up through the throttle plate(s). In addition to improper engine operation, a blocked or restricted exhaust system causes increased noise and air pollution. Leaks in the exhaust system caused by either physical or chemical (rust) damage could result in illness, asphyxiation, or even death.

a) Exhaust System Inspection

Most parts of the exhaust system, particularly the exhaust pipe, muffler, and tailpipe, are subject to rust, corrosion, and cracking. Broken or loose clamps and hangers can allow parts to separate or hit the road asthe car moves. All inspections should include listening for abnormal noises. The inspection should also include a careful look at the system while the vehicle is raised on a hoist. Before beginning work on the system, be sure that it is cool to the touch. Some technicians disconnect the battery ground to avoid short-circuiting the electrical system.

b) Exhaust Restriction

Test Often leaks and rattles are the only things looked for in an exhaust system. The exhaust system should also be tested for blockage and restrictions. Collapsed pipes or clogged converters and/or mufflers can cause these blockages. There are many ways to check for a restricted exhaust. The sound of the exhaust can indicate a restriction. Although this is not the most effective way to determine if thereis a restriction, it is a good start.

Checking the pressure built up in the exhaust is the best way to determine if the system is blocked. This is done by installing a pressure gauge in the O2S bore in the exhaust pipe. At idle, the gauge should read less than 1.5 psi (10 kPa) and should be less than 2.5 psi (17 kPa) at 2,500 rpm. Some technicians check for a restricted exhaust with a vacuum gauge. With the gauge connected to the intake manifold, the engine's speed is raised and held. The vacuum reading should rise and either hold there or increase slightly. If the vacuum decreases, there is an exhaust restriction.

c) Exhaust Leaks

Exhaust leaks are often identified by sound, although very small leaks can be difficult to locate. One of the most effective ways to identify the source of a leak in the system is the use of a smokemachine. When smoke is introduced to the exhaust system, a trace of smoke will identify the source of the leak.

d) Exhaust Manifold Servicing

an exhaust manifold will warp because of excess heat. A straightedge and feeler gauge can be used tocheck the machined surface of the manifold. Another problem—also the result of high temperatures generated by the engine—is a cracked manifold. This usually occurs after the car passes through alarge puddle and cold water splashes on the manifold's hot surface. If the manifold is warped beyondmanufacturer's specifications or is cracked, it must be replaced.

e) Replacing Leaking Gaskets and Seals

The most likely spot to find leaking gaskets and seals is between the exhaust manifold and the exhaust pipe Most often exhaust bolts are quite rusted and can be difficult to loosen. This is why it is wise to soak the bolts and nuts with penetrating fluid before attempting to disassemble the system.. To replace an exhaust manifold gasket, follow the torque sequence in reverse to loosen each bolt. Repeat the process to remove the bolts. Doing this minimizes the chance that components will warp. Inspect the manifold for irregularities that might cause leaks, such as, scratches, or cracks.

Replace it if it is cracked or badly warped. Then during Install the bolts or nuts finger-tight. Tighten themin three steps—one-half, three-quarters, and full torque. Always follow the specifications given for thatengine. Normally the nuts should be tightened in a particular sequence. This sequence typically beginsat the center and continues outward in an X pattern.

f) Replacing Exhaust Pipes

In most cases, the exhaust system is replaced as a unit. Doing this ensures a proper fit and saves much time. However, there are times when only a section or component needs to bereplaced. When doing this take care not to damage any surrounding parts. To replace an exhaust pipe,support the converter to keep it from falling and remove the O2S. Remove any hangers or clamps holding the exhaust pipe to the frame. Unbolt the flange holding the exhaust pipe to the exhaust manifold.

Disconnect the pipe from the converter and pull the front exhaust pipe loose and remove it. If the pipe issealed with a gasket, replace it when installing the new pipe.

2.5.4 Fuel system

Automobile engines mostly use two types of fuels gasoline and diesel fuel. These fuels must reach to the engine cylinders and be ignited. Three basic types of fuel systems are used in automobile engines

1. Gasoline fuel systems (carburetor and gasoline fuel injection)
2. Diesel fuel system

A. Gasoline fuel systems

Gasoline is a hydrocarbon (abbreviated HC), made up largely of hydrogen and carbon compounds. In +8-3 there is an explanation of what happens in the engine when gasoline is burned.

In this system, the carburetor is replaced by a toe body whose only purpose is to control the amount of air entering the intake manifold. Most fuel-injection systems include a fuel pump, fuel lines, an electronic control unit, and one or more fuel-injection valves. The injection valve is a nozzle with a small hole through which fuel is sprayed on a signal from the electronic control unit.

1.1 Components

The carbureted fuel system consists of the fuel tank, fuel pump, fuel filter, carburetor, intake manifold, and fuel lines. The fuel lines are tubes connecting the tank, fuel pump, and carburetor. Most of these components are the same in both the carbureted and the fuel-injection systems. Each component is described in following sections.

B. Fuel tank

The fuel tank is normally located at the rear of the vehicle. It is usually made of sheet metal or plastic. It is attached to the frame or body. The filler opening of the tank 'is closed by a cap. The fuel line is attached to a pickup tube which is usually part of the tank fuel-gauge assembly. In most tanks, there is a strainer on the end of the fuel-pickup tube. Fuel tanks in older cars have a vent pipe to allow air to escape when the tank is being filled.

Vaporized fuel (HC) escaping from the fuel tank through the vent pipe contributes to air pollution. Therefore, cars manufactured since 1970 have been equipped with an evaporative emission control system. In this system, the fuel-tank vent is connected to a charcoal canister. It holds the vapor and prevents its escape into the air.

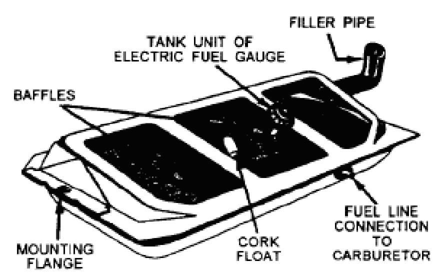


Figure 2-23 Fuel tank

C. Fuel Filters And Screens

Fuel Systems have filters and screens to prevent dirt in the fuel from entering the fuel pump or carburetor. Dirt could prevent normal operation of these units and because poor engine performance, filters may be a separate unit connected into the fuel line between the tank and the fuel pump, or between the fuel pump and the carburetor, or in or on the carburetor itself.

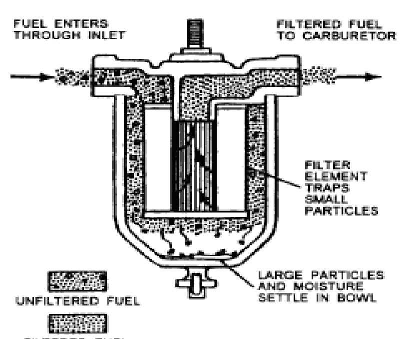


Figure 2-24 Fuel Filters and Screens

D. Fuel gauge

There are two types of fuel gauges, magnetic and thermostatic. Each of these gauges has a tank unit and an instrument panel unit.

iii. **Magnetic: -** The tank unit in this fuel gauge contains a sliding contact. The contact slides back and forth on a resistor as the float moves up and down in the fuel tank. This change the amount of electric resistance the tank unit offers. As the tank empties, the float drops and the sliding contact moves to reduce the resistance. The instrument panel unit contains two coils. When the ignition switch is turned on, current from the battery flows through the two coils. This produces a magnetic field that acts on the armature, to which the pointer is attached.

E. **Thermostatic:** - It has a fuel-tank unit much like the magnetic system. The tank unit has a float and a sliding contact that moves on a resistor. Current flows from the battery through the, resistance in the tank unit. When the fuel is low in the tank, most of the resistance is in the circuit. Very little current can flow. When the tank is filled, the float moves up, and the sliding contact cuts most of the resistance out of the circuit. Now more current flows. As it flows through the heater coil in the fuel gauge, the current heats the thermostat.

F. Fuel Lines and Hoses

Fuel lines and hoses carry fuel from the tank to the engine. The main fuel line allows the fuel pump to draw fuel out of the tank. The fuel is pulled through this line to the pump and then to the carburetor, or metering section of the injection system.

G. Air Cleaner

The fuel system mixes air and fuel to produce a combustible mixture. A large volume of air passes through the carburetor or fuel injection system and engine. Air always contains a lot of floating dust and grit. The dust and grit could cause serious damage if they entered the engine. To prevent this, an air cleaner is mounted at the air entrance of the carburetor or fuel injection system. The two types of cleaners currently used are the wet and dry types.

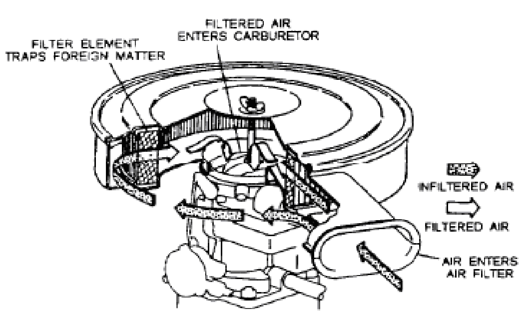


Figure 2-26 Dry type air cleaner

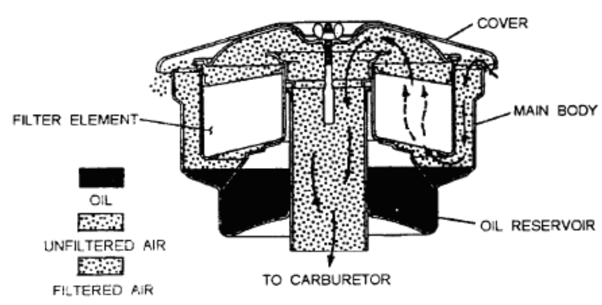


Figure 2-25 Wet type air cleaner

H. Gasoline fuel pumps

Gasoline fuel pump is a device, which delivers fuel from the tank to the carburetor. Fuel pumps are generally of two types: Mechanical and Electrical pumps.

A. Mechanical fuel pump

Four stroke spark ignition engines are in most cases equipped with a mechanical diaphragm type pump. The main distinction between the various types of diaphragm pump is the drive principle: they can be operated by a cam and lever, by levers from pushrod or by a plunger.

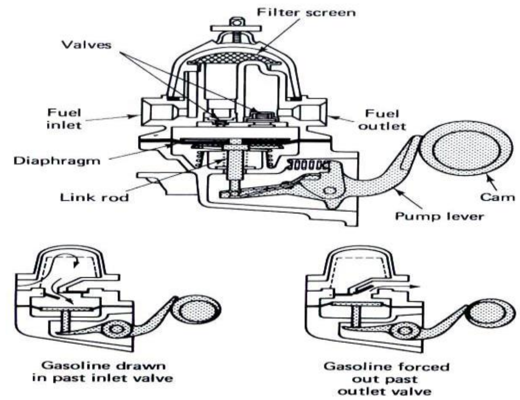


Figure 2-27 Mechanical fuel pump

The pump, figure 1 consists of a spring laded flexible diaphragm, usually made from laminated synthetic rubber and nylon fabric, sandwiched between an upper valve- chamber housing and a lower pull-rod housing which is attached to the engine. Built into the upper chamber there are pair of inlet and outlet valves.

B. Electrical fuel pumps

Electrical fuel pumps have certain advantages over mechanical fuel pumps. Fuel is at the carburetor as soon as the ignition switch is turned on. The pump can deliver more fuel than the engine will require even under maximum operating conditions. Thus, the engine will never be fuel – starved. They are, therefore, used in many high performance and heavy- duty application.

Figure 2-28 Electrical fuel pumps

There are various types of electric fuel pumps. One of the latest types is mounted in the fuel tank. It contains an impeller driven by an electric motor. This pushes fuel through the fuel line to the carburetor. Other types are mounted in the engine compartment.

1.2 Carburetor terminologies

A. Carburetion

Carburetion is the mixing of the gasoline fuel with air to get a combustible mixture. The function of the carburetor is to supply a combustible mixture of varying degrees of richness to suit engine operating connections. The mixture must be rich (have a higher percentage of fuel) for starting, acceleration, and high-speed operation. A less rich (leaner) mixture is desirable at intermediate speed with a warm engine. The carburetor has several systems through which .air-fuel mixture II flows during different operating conditions. These systems produce the varying mixtures required for the different operating conditions.

B. Vaporization

When a liquid changes to a vapor, it is said to evaporate. Water placed in an open pan will evaporate. The water changes from a liquid to a vapor, Wet clothes hung on a line dry: the water in the clothes turns to vapor. When the clothes are spread out, they dry more rapidly than when they are bunched together. This illustrates an important fact about evaporation. The greater the surface exposed, the more rapidly evaporation takes place. Water in a tall glass takes longer to evaporate than water in a shallow pan. Much more area is exposed in the pan

C. **Atomization**

To produce very quick vaporization of the liquid gasoline, it is sprayed into the air passing through the carburetor. Spraying the liquid turns into many fine droplets. This effect is called atomization because the liquid is broken up into small droplets (but not actually into atoms, as the name implies). Each droplet is exposed to air on all sides so that it vaporizes very quickly. Therefore, during normal running of the engine, the fuel sprayed into the air passing through the carburetor turns to vapor.

D. Venturi Effect

The engine is, in a sense, a vacuum pump. As the pistons move down on the intake strokes, a partial vacuum is produced in the cylinders. A partial vacuum is any pressure less than atmospheric pressure. Atmospheric pressure pushes air, or air-fuel mixture, into the cylinders to fill the vacuum. As the air flows toward the engine cylinders, it must first pass through the carburetor. A venturi is located in the air passage through the carburetor. As the air flows through the venturi, a partial vacuum is produced in it. The venturi restricts the flow of air so that the air pressure in the venturi is reduced. The air particles before the venturi are at atmospheric pressure (normal air pressure) But as they move through the venturi, they speed up and spread out (pressure drops, or a partial vacuum develops).

The fuel nozzle is located in the venturi. Atmospheric pressure is pushing down on the fuel in the float bowl. Since there is a partial vacuum around the venturi end of the fuel nozzle (the pressure is lower), atmospheric pressure pushes fuel up through the nozzle and into the air flowing through the venturi. The fuel sprays out, or atomizes, and quickly turns to vapor.

E. Throttle Valve action

The throttle valve is a round disk below the venturi and fuel nozzle in the carburetor. The air horn is the round cylinder through which air flows on its way to the engine cylinders. The air picks up a change of fuel vapor while passing through the venturi. The throttle valve can be tilted more or less to allow more or less air-fuel mixture to flow through. More air flowing through the venturi increases the venturi vacuum. This causes more fuel to flow from the nozzle. If the throttle valve is tilted toward the closed position less air will flow. The vacuum in. the venturi will be less. Therefore less fuel will discharge into the passing air.

F. Air-fuel-ratio requirements

The fuel system must vary the air-fuel ratio to suit different operating requirements. The mixture must be rich (have a high proportion of fuel) for starting. It must be leaner (have a lower proportion of fuel for part-throttle medium-speed operation. Ratios, and the speeds at which they are obtained, vary with different cars. In the example shown in, a rich mixture of about 9:1 '(9 pounds [4 kg] of air for each pound [0.45 kg] of fuel) is supplied for starting. Then, during idle, the mixture leans out to about 12:1. At medium speeds, the mixture further leans out to about 15:1 or leaner. Some engines run on mixtures as lean as 20:1. But at higher speeds, with a wide-open throttle, the mixture is enriched to about 13:1. Opening the throttle for acceleration at any speed causes a momentary enrichment of the mixture.

.The following sections describe the various systems in carburetors that supply the air-fuel mixture required for different operating conditions.

In many late-model cars, the air-fuel 'ratio is controlled electronically. The electronic control systems are explained in the chapter on emission controls.

1.3 Carburetor Systems

The systems (or circuits as they are sometimes called) in the carburetor are

1. The float system

This system maintains a steady working supply of gasoline at a constant level in the carburetor. This action is critical to the proper operation of the carburetor. Since the carburetor uses differences in pressure to force fuel into the air horn. The float system keeps the fuel pump from forcing too much gasoline into the carburetor bowl.

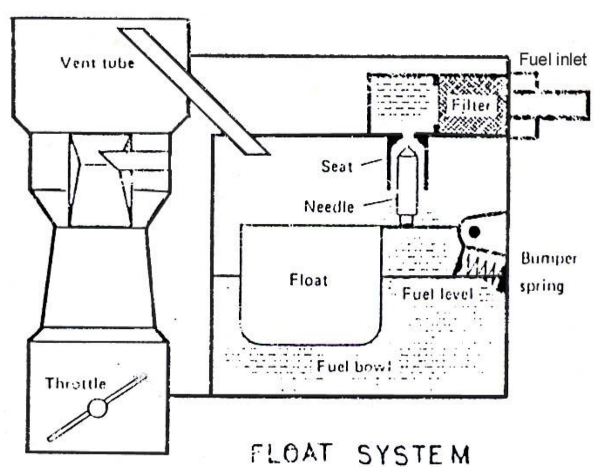


Figure 2-29 Float system

The basic parts of the float system are the fuel bowl, the float, the needle valve, the needle seat, the bowl vent.

2. **Idle system (no load operation)**

The throttle valve is closed during engine idling. Therefore, the vacuum in the intake manifold (below the throttle valve) is high. The vacuum in the intake manifold decreases as the throttle opens. The vacuum in the intake manifold draws the air-fuel mixture via the idle port. The amount of air –fuel mixture is controlled by an idle-mixture screw.

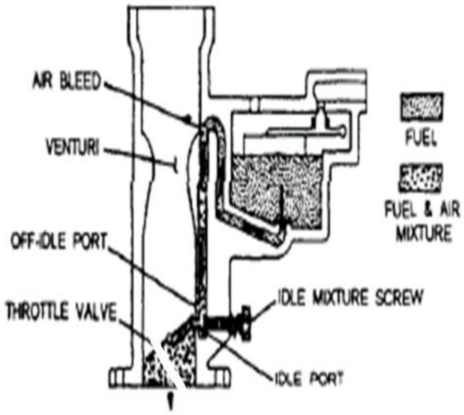
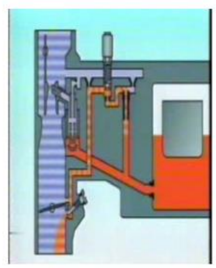


Figure .—Idle system.



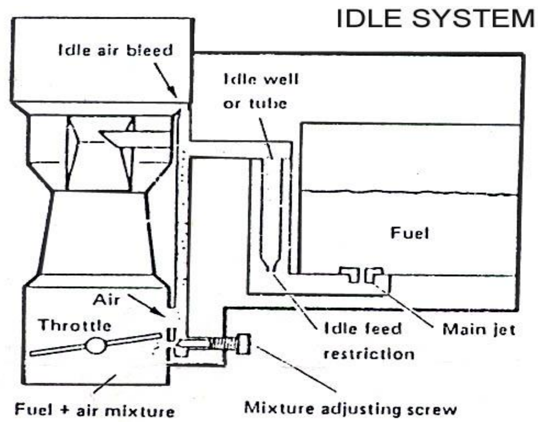


Figure 2-30 Idle system

3. **Off idle system (low speed operation)**

The off idle, also known as the part throttle, feeds more fuel into the air horn when the throttle plate is partially open. Air – fuel mixture is drawn from both the idle and low speed ports. It is an extension of the idle system. It functions above approximately 800 rpm or 20 mph. Without the off idle system, the fuel mixture would become too lean slightly above idle. The idle system alone is not capable of supplying enough fuel to the air stream passing through the carburetor.

4. **Acceleration system**

The carburetor acceleration system, like the off idle system, provides extra fuel when changing from the idle system to the high-speed system.

The acceleration system squirts a stream of fuel into the air horn when the fuel pedal is pressed and the throttle plates swing open. Without the acceleration system, too much air would rush into the engine, as the throttle quickly opened.

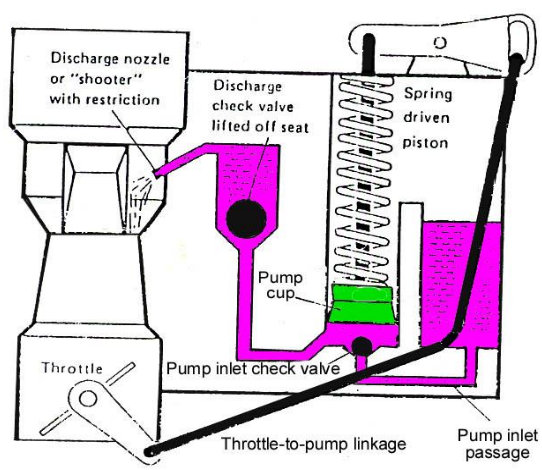


Figure 2-31 Acceleration system

The mixture would become too lean for combustion and the engine would *stall* or *hesitate*. The acceleration system prevents a lean air-fuel mixture from upsetting a smooth increase in engine speed.

5. High-Speed System (Main metering system)

The, high-speed system, also called the main metering system, supplies the engine air-fuel mixture at normal cruising speeds. As the throttle valve opens further, the vacuum near the throttle valve decreases, and the flow from the idle and low speed ports stop.

The fuel is now supplied from the main nozzle. As the throttle valve opens wider, air flow, venture throat vacuum, fuel flow.

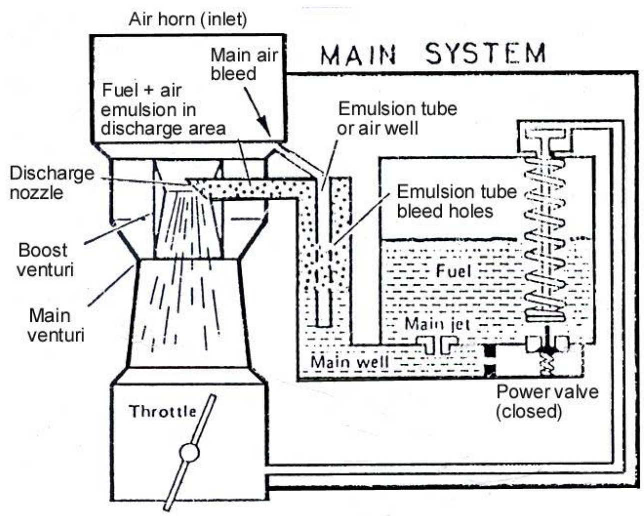


Figure 2-32 High-Speed System

6. Full-Power System

The full-power system provides a means of enriching the fuel mixture for high-speed, high-power conditions. This system operates, for example, when the driver presses the fuel pedal to pass another vehicle or to climb a steep hill.

The full-power system is an addition to the high-speed system. Either a metering rod or a power valve (jet) can be used to provide variable, high-speed air-fuel ratio.

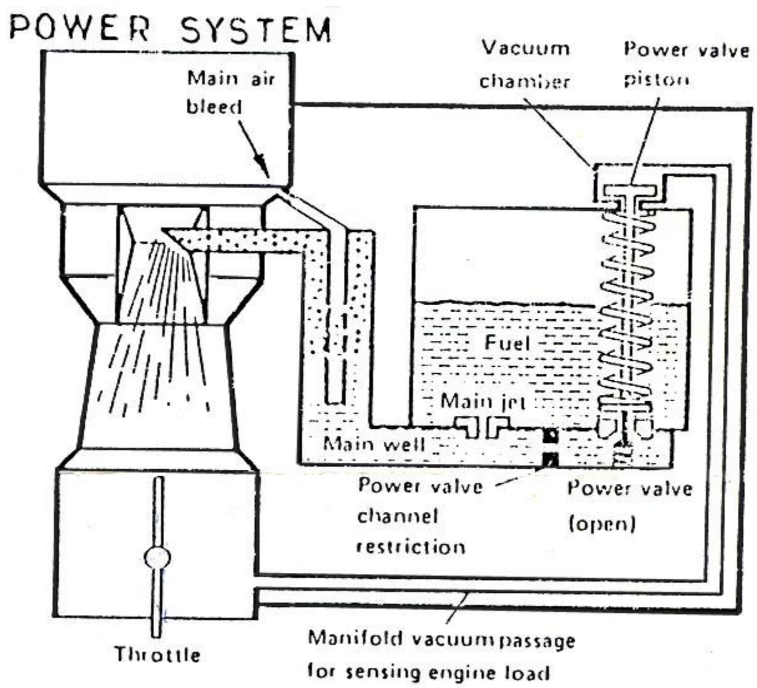


Figure 2-33 Full-Power System

7. Choke System

With the carburetor and engine cold, only part of the fuel evaporates. Same fuel condenses on the cold intake manifold walls Extra fuel is needed so enough will vaporize to produce a combustible mixture.

To start a cold engine, the carburetor must deliver a very rich mixture. The choke valve produces the required fuel enrichment during engine cold start.

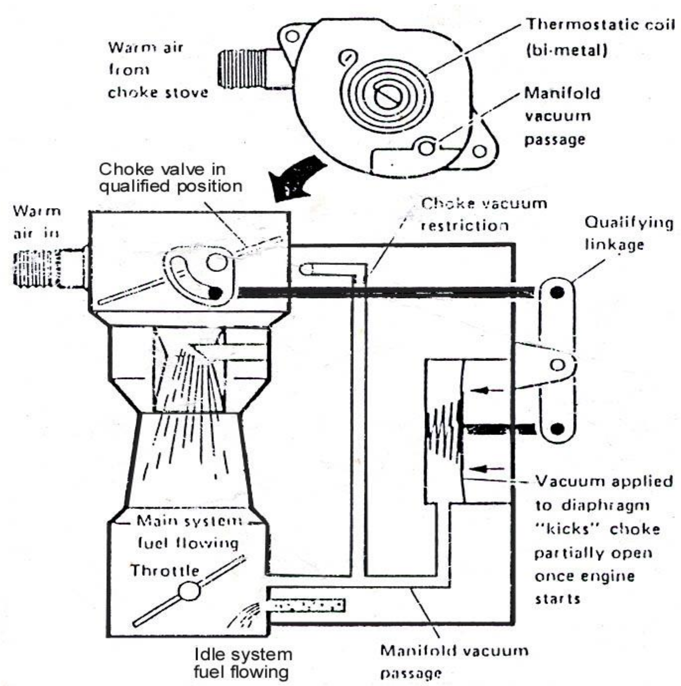


Figure 2-34 Choke system

1.4 Carburetor accessories

There are several devices used on carburetors to improve drivability and economy. These devices are as follows: the fast idle solenoid, the throttle return dashpot, the hot idle compensator, and the altitude compensator. Their applications vary from vehicle to vehicle.

- **Fast Idle Solenoid**

A fast idle solenoid, also known as an anti-dieseling solenoid, opens the carburetor throttle plates during engine operation but allows the throttle plates to close as soon as the engine is turned off. In this way, a faster idle speed can be used while still avoiding dieseling (engine keeps running even though the ignition key is turned off). This is a particular problem with newer emission controlled vehicles due to higher operating temperatures, higher idle speeds, leaner fuel mixtures, and lower octane fuel.

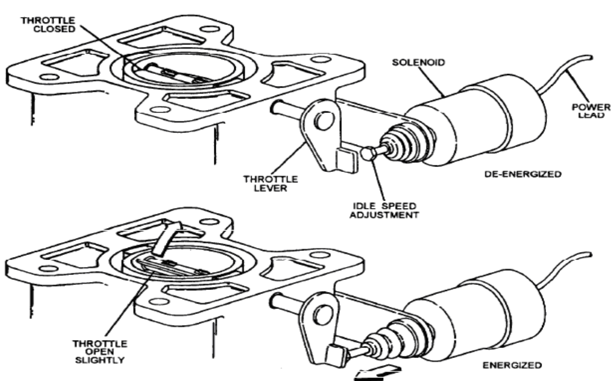


Figure 2-35 Anti dieseling solenoid operation

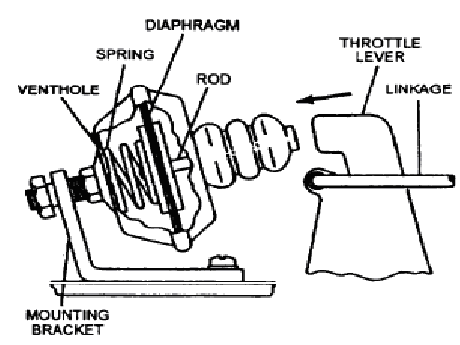


Figure 2-36 Throttle return dashpot

Throttle Return Dashpot

The throttle return dashpot, also known as an anti-stall dashpot, acts as a damper to keep the throttle from closing too quickly when the accelerator pedal is suddenly released. It is commonly used on carburetors for automatic transmission equipped vehicles. Without the throttle return dashpot, the engine could stall when the engine quickly returned to idle. The drag of the automatic transmission could kill the engine. The throttle return dashpot works something like a shock absorber. It uses a spring-loaded diaphragm mounted in a sealed housing. A small hole is drilled into the diaphragm housing to prevent rapid movement of the dashpot plunger and diaphragm. Air must bleed out of the hole slowly.

When the vehicle is traveling down the road (throttle plates open), the spring pushes the dashpot plunger forward. When the engine returns to idle, the throttle lever strikes the extended dashpot plunger, and air leaks out of the throttle return dashpot, returning the engine slowly to curb idle. This action gives the automatic transmission enough time to disconnect (torque converter releases) from the engine without the engine stalling.

Hot Idle Compensator

A hot idle compensator (figure 3.38) is a thermostatically controlled device that prevents engine stalling or a rough idle under high engine temperatures. The temperature sensitive valve admits extra air into the engine to increase idle speed and smoothness.

At normal engine temperatures, the hot-idle compensator valve remains closed, and the engine idles normally. When temperatures are high (prolonged idling periods, for example), fuel vapors can enter the air horn and enrich the air-fuel mixture. The hot idle compensator opens to allow extra air to enter the intake manifold. This action compensates for the extra fuel vapors and corrects the air-fuel mixture.

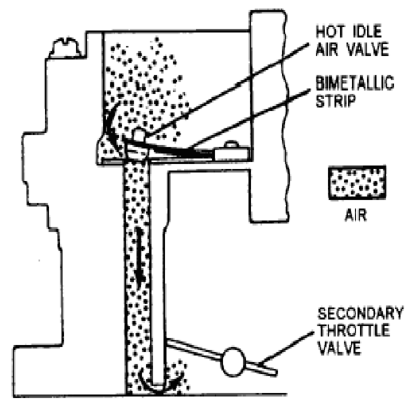


Figure 2-37 Hot Idle Compensator

Altitude Compensator

An altitude compensator is used to change the air-fuel mixture in the carburetor with changes in the vehicle height above sea level. Normally the compensator is an aneroid device (bellows device that expands and contracts with changes in atmospheric pressure).

As a vehicle is driven up a mountain, the density of the air decreases. This condition tends to make the air-fuel mixture richer. The reduced air pressure causes the aneroid to expand, opening an air valve. Extra air flows into the air horn and the air-fuel mixture becomes leaner.

B. Diesel-Engine Fuel Systems

The automotive diesel-engine fuel system 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.

i. Constructions and operation

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. 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.

- **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**

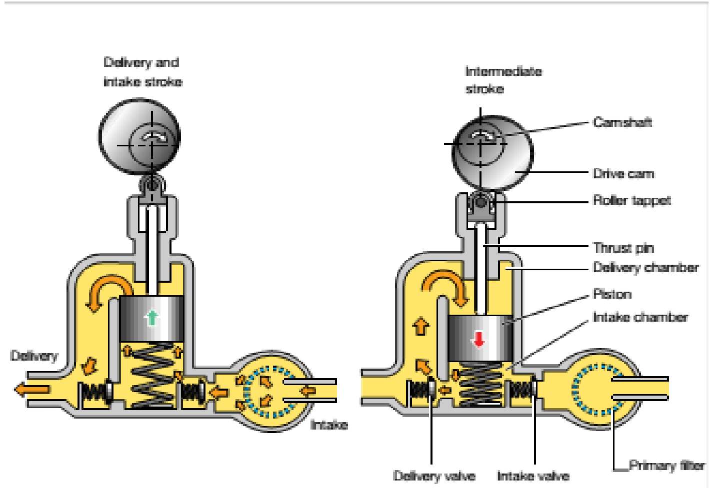


Figure 2-38 Supply pump

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.

- **Fuel filter**

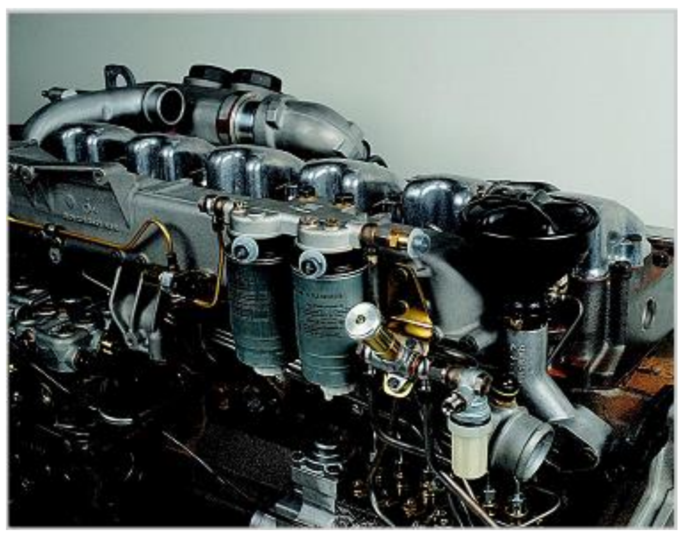


Figure 2-39 Fuel filter

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 millimeter. 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).

- **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.

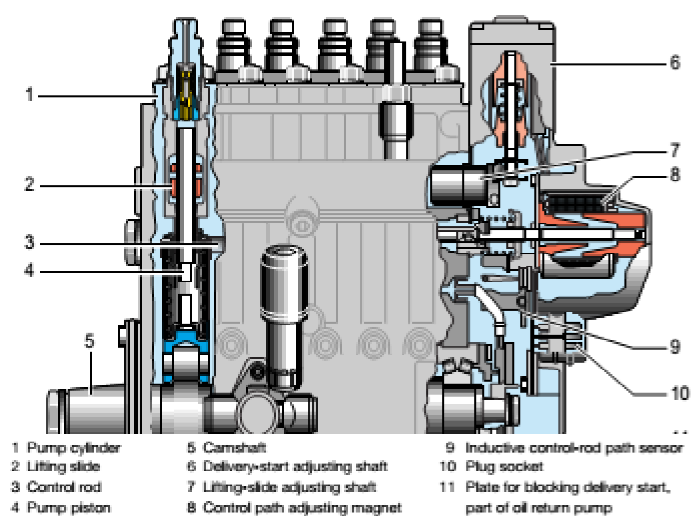


Figure 2-40 Operating principle of the lifting-slide inline injection pump & mechanical in line pump

- **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.

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.

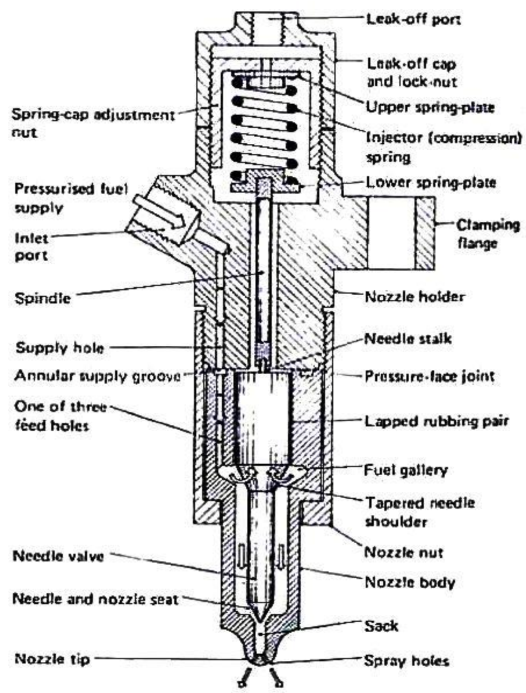


Figure 2-41 Sectional view of injector

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.

Bleeding Diesel 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.

Injection timing

a) Timing device

1. 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.
2. 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.
3. 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.
4. 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.
5. 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.

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.

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.

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

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.

12. 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.

Self-check 2

1) If the cylinder head is defective, which of the following will leak into the cooling system?

   A. air-fuel mixture   B. fuel   C. combustion gases   D. exhaust

2) 2) Leakage of gases into the cooling system may form

   A. oil sludge   B. carbon deposits   C. strong acids   D. scales

3) The acids that form in the cooling system may corrode the

   A. radiator   B. temperature gauge   C. thermostat   D. water pumping

4) Combustion leaks in the valve areas can cause cracks in the

   A. cylinder and piston   B. valve seats and cylinder heads

   C. crank shaft and camshaft   D. oil pan and timing cover

5) Combustion leak in the valve area can be stopped by

   A. replacing cylinder head gasket   B. grinding the valve face and valve seat

   C. replacing the piston ring   D. none of the above

6) Which of the flowing oil contains that is located at the bottom of the engine.

   A) Oil pan   B) Oil   c) Dip stick   D) all

7) Which of the Metal mesh located at the oil inlet to remove large dust particles.

   A) Sump   B) Oil   c) Oil strainer   D) All

8) Pumps oil that has accumulated in the oil pan to the various areas of the engine.

   A) Oil filter   B) Oil pressure switch   c) Dip stick (Level gauge)   D) Oil pump

9) ___________, located between the catalytic converter and the resonator or tail pipe, contains perforated pipes, baffles, and resonance chambers.

   A) Muffler   B) Exhaust manifold   C) catalytic converter

10) ______________is a long pipe leading from the exhaust manifold to the muffler.

   A) Muffler   B) Exhaust pipe   c) Tail pipe   D) All

Operation sheet-1

Title: Removing and Disassemble Cooling system

Objectives: Given an engine, ultraviolet light, special dye, paper and pencil and clean rags, you will perform leak test, record, analyze results and prescribe action.

Instructions:

1. Prepare tools/equipment needed.

2. Wear protective clothing and goggles.

3. Add the specified amount of special dye to the coolant.

4. With the heater on, run the engine until the upper radiator tank hose is warm.

5. Aim the ultraviolet light at the suspected heating area. (Note: the dye in the coolant will cause any leaking coolant to glow bright green)

6. Identify and record the part of the engine where the leakage occurs.

7. Analyze if the leakage is caused by worn-out gaskets, broken parts, loose fasteners, etc.

8. Indicate preferred corrective actions. (Note: For the data in numbers 4,5 and 6, use the attached worksheet

Operation sheet-2

Title: Removing and Disassemble Lubrication system

Objectives: Given an engine, ultraviolet light, special dye, paper and pencil and clean rags, you will perform leak test, record, analyze results and prescribe action.

Instructions:

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.

Operation sheet-3

Title: Bleeding the Fuel System

Objectives: Given an engine, ultraviolet light, special dye, paper and pencil and clean rags, you will perform leak test, record, analyze results and prescribe action.

Instructions

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.

9) Be sure there is a sufficient supply of fuel in the fuel tank.

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

11. Start the electric fuel pump by turning the ignition key to the "ON"

12. 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.

13. Slowly loosen the air bleed plug on the fuel filter, letting air escape until an air free flow of fuel is evident.

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

15. 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.

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

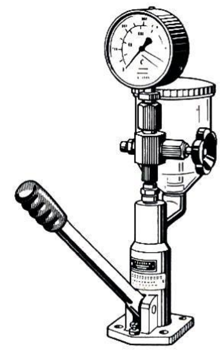
17. The fuel system should now be properly bled and ready for operation.

Refer to starting instructions before attempting to start the engine after bleeding the fuel system

Operation sheet-4

Title: Bleeding the Fuel System

Objectives: Given an engine, ultraviolet light, special dye, paper and pencil and clean rags, you will perform leak test, record, analyze results and prescribe action.

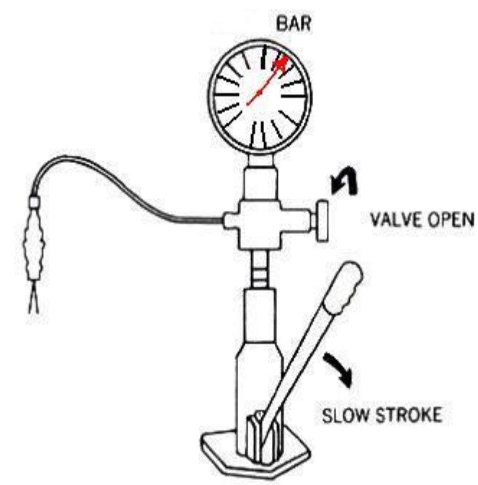


Instructions

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.

Testing Injector Nozzle

Before disassembling an injector an important step is to ***test*** it. The injector is connected to the pressure line of the injector tester, and tightened after the air is removed.



Perform the testes in the Following order:-

a. Opening pressure test
b. Leakage or valve-seat test
c. Back leakage test
d. Spray pattern test

Adjusting injection nozzle Opening Pressure

Testing Procedure:

a. Open the pressure gauge isolator after bleeding the system.
b. Operate the lever of the tester slowly until injection occurs.
c. Observe the pressure gauge and note highest reading just before injection pressure begins to drop.
d. Compare the recorded opening pressure reading with manufacturer's specification. If the actual pressure varies from the standard, the pre-tension of the pressure spring has to be adjusted. This is done by the adjustment screw provided, or by adjusting shims of various sizes. Adjusting Shims are usually available in sizes from **1.0 - 3.0mm** thickness and in steps of **0.05mm**.

Checking injection nozzle back Leakage Test

After the leakage or valve-seat test, some manufacturers recommend to perform a back leakage test.

Testing Procedure:

a. Open the pressure gauge isolator on the tester.

b. Slowly depress the operating lever until stated pressure is shown on gauge.

c. Release the operating lever and note the time taken for pressure to fall.

The time for the pressure drop can be influenced by: -

1. The fuel temperature
2. The viscosity of the test fluid used
3. The length of the pressure line used.

Results

Generally, a pressure drop from 150 to 100 bar ($\Delta P \approx 50$ bar) within a time not less than 6 seconds ($T \geq 6$ second), using shelf fluid "C" and maintaining a test temperature approximately 10^0 up to 20^0c indicates a satisfactory injector.

A higher pressure drops than specified can be caused by: -

a. Loose fuel pipe connections

b. High temperatures, causing thinning of the test oil

c. Loose nozzle cap or nozzle holder retaining nut.

d. Dirty or damaged sealing surfaces of nozzle and/or nozzle holder, which allows fuel to escape.

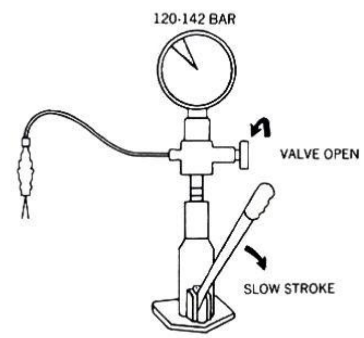
Checking injection nozzle Leakage or Valve-Seat

Testing Procedure:

a. Open the pressure gauge isolator and wipe injector tip dry.

b. Depress the operating level of the tester slowly until the gauge indicates a pressure of about 10 to 20 bar below the before-measured opening pressure.

c. Maintain this pressure for 10 seconds and observe the injector tip.



Results

If no fuel drop occurs during this time, the needle-valve seat is in good condition. If there is any evidence of fuel at the tip, the needle-valve seat is defective. The nozzle assembly should be replaced or overhauled.

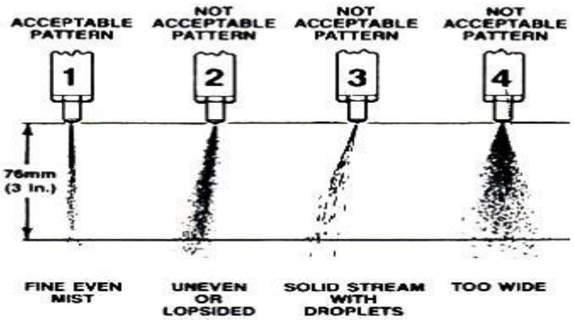
Checking injection nozzle Spray Pattern

Testing Procedure:

a. Close the pressure gauge isolator on the tester.

b. Move the opening lever at about 1 strokes/second and observe the spray jet. A nozzle in good condition shows a thin and even cone-shaped jet of spray without distortion and fine atomized fuel.

c. After this, gradually increase the lever movement to about 2 strokes per second.



Results

Now a characteristic "chattering or humming" sound should be noticed indicating a properly working injector. This depends also very much on the test fluid used. If the injector does not atomize the fuel completely, incomplete combustion, causing black smoke, a loss in engine power and poor fuel economy, will result, Increased diesel knock, due to the longer delay period that follows poor atomization, will also be evident.

LAP- Test

Instructions:

1. You are required to perform any of the following:

    - how to identifying the cooling system components
    - Performing diesel fuel system bleeding
    - Check timing of diesel engine
    - Find the suitable oil for refilling the fresh oil and

Unit Three: Replace/Reassemble System Assemblies

This unit to provide you the necessary information regarding the following content coverage and topics:

- Carryout minor adjustments
- Assembling system components
- Conducting post-service/pre-delivery check

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:

- Carry out minor adjustments
- Assemble system components
- Conduct post-service/pre-delivery check

3.1 Carrying out minor 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. 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.

3.1.1 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.

3.1.2 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.

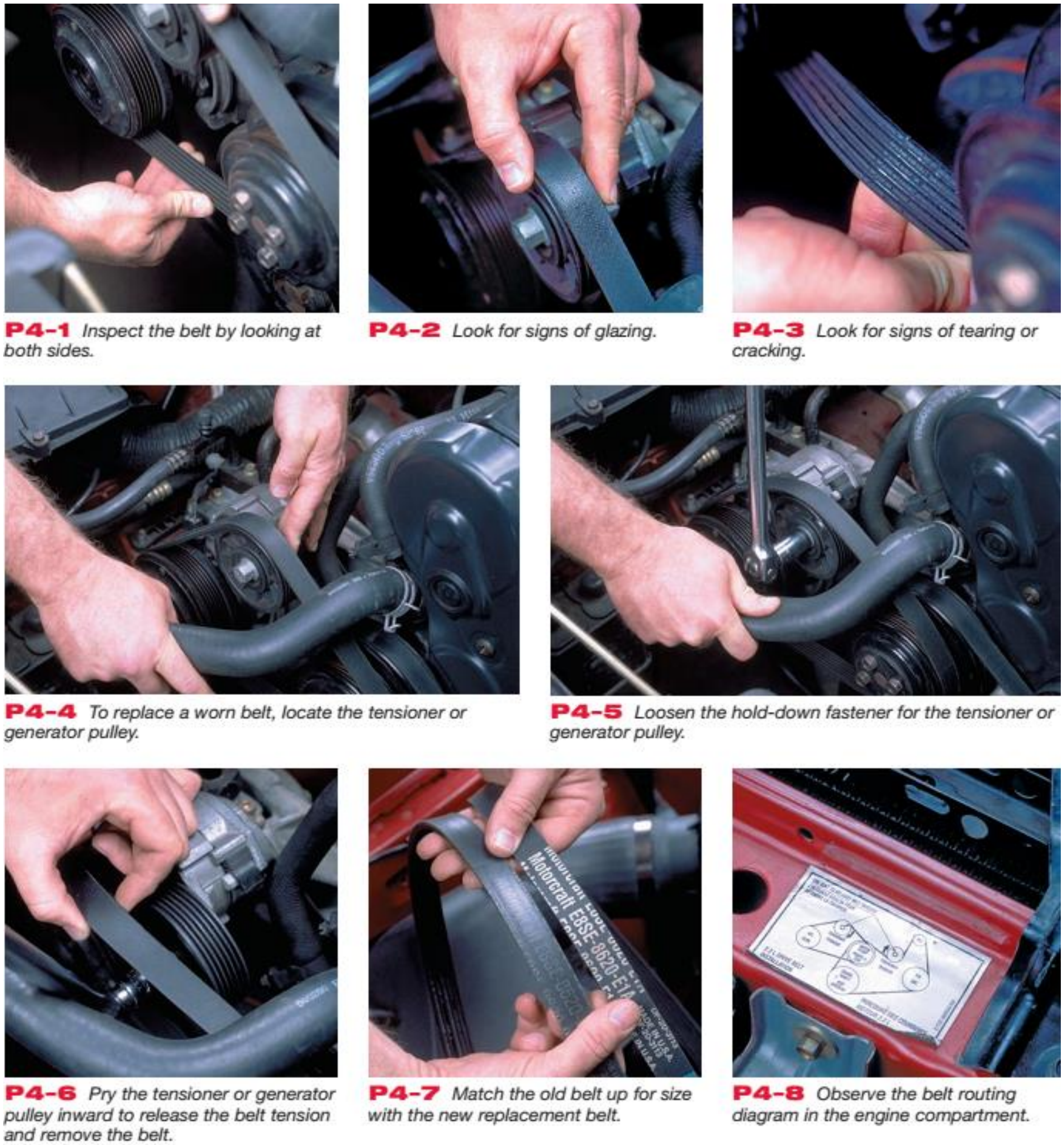
A. **Inspection** Even the best drive belts last only an average of 4 years. That time can be shortened by several things; most of these can be found by inspecting the belts. Check the condition of all of the drive belts on the engine. Carefully look to see if they have worn or glazed edges, tears, splits, 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.

B. **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.



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.

Figure 3-1 checking Belt

3.2 Assembling system components

- Connect the injector nozzle leak off pipe assembly
- Connect the cooling system
- Connect the exhaust pipe
- Connect the injector nozzle leak off pipe assembly
- Connect the fuel pipes from the fuel injection pump outlet and inlet to filter
- Connect fuel pipe from fuel lift pump outlet to fuel filter. Remove fuel filter

- Connect high pressure fuel pipes and nozzles
- Connect fuel pipe and electrical lead at the thermostat.
- Connect air filter and / or connecting hose
- Connect induction and exhaust manifold
- Connect the cooling system
- Connect fuel pipe and electrical lead at the thermostat.
- Remove air filter and / or connecting hose
- Remove induction and exhaust manifolds

3.3 Conducting post-service/pre-delivery check

3.3.1 Document result with evidence

Documentation provides valuable descriptions of an organization's development, acquisition, and operating environments and significantly enhances an organization's ability to administer, operate, and maintain technology systems. Primary advantages for technicians' involve having access to operation manuals and on-line application help features. Documentation enhances administrators' and technicians' ability to maintain and update systems efficiently and to identify and correct programming defects.

Developing and maintaining current, accurate documentation can be complicated, time consuming, and expensive. However, standardized documentation procedures and the use of automated documentation software can facilitate an organization's ability to maintain accurate documentation.

3.3.2 Final Inspection

Consumers' expectations are that they will receive their vehicle back in a serviceable condition and in a better operational condition than when it was delivered to the workshop. This expectation requires two (2) critical components:

- A final inspection must be completed by the service technician to ensure that all of the protective features for the braking system have been refitted is replaced to the required specifications; and
- A final inspection must be completed by the service technician to ensure that all of the work that was commenced on the system was completed to workplace, customer and manufacturers expectations.

3.3.3 Service provision

There are some tasks that a technician will not carry out frequently. It would be unrealistic for a technician to have a detailed knowledge of seldom-performed procedures. In these circumstances, job cards or checklists are very useful as they give a step-by-step guide to follow whenever the rarely-used procedure needs to be performed. The required knowledge is often kept in manuals which may not be easily accessible. However, going through a large manual, possibly in front of a customer, does nothing for time effectiveness or professional image.

A job card is also used as the basis of a recording process for the organization. In addition to refreshing the process for the technician it will be a list of the workplace expectations as well. It is suggested that the final task on a job card will be to ensure that the equipment is cleaned for use or storage.

3.3.4 Noting and documenting observations during the service

The most precise way to document instruction is to create a Running Record, or virtual transcript, noting what was observed every two minutes.

Direct observation of behaviors is important for many reasons. It is a means of generating hypotheses and new ideas or a means of answering specific questions. Observations also enable us to answer questions about what happens during repairing. For the purpose of these observations, time sampling is used to record engine parts repairing.

An observer should attend to all contextual details on the parts of engine repair. Observers do not make any assumptions at any time. They do not assume that any event is instructionally relevant or irrelevant. Observers should avoid biases based on personal preferences or practice. That is, when assigned to observe a particular instructional program, observers do not judge the engine parts or specific activities during repairing.

Observers must record what kind of an engine part is repaired without making ongoing judgments about the quality of engine part repairing or the effective use of a particular technique. The observer's job is to capture what happened, not his or her opinion of what happened. After noting and documenting the observation during the repair every technician should complete work shop practice schedule documentation.

Follow these three general principles to develop records and documents:

1. Keep it short and simple. Use bullet points and flow diagrams instead of long sentences and lengthy paragraphs.
2. Clarity is important. Step-by-step instructions are easily understood.

3. Use a standardized, consistent format. Although different programs may need different documents and records, using a similar approach will help staff learn quickly.

3.3.5 Completing and delivering report to appropriate person

Delivery is the process of transporting something/ like reports/ from a source location to a predefined destination after the work is done. The technician should be prepare a report and deliver to appropriate person. The reporting procedures are as follows

- Record the work to be done
- Inspect/test the repaired engine accordance with manufacturer procedure
- Record/ capture the problem with the necessary information
- Order the recorded problems /work done in accordance with their damaging area
- Preparing reports have no error/discrepancy
- Deliver reports to appropriate person.

Self-check 3

Short answer

1. How do we check the Coolant Condition?
2. During the final Inspection what requires critical components?
3. What are the general principles to develop records and documents?
4. List the procedures of reporting

Unit Four: Cleanup work area and maintain equipment

This unit is developed to provide you the necessary information regarding the following content coverage and topics:
• Waste and scrap materials • Hazardous goods and substances • Tools equipment • Workplace documentation and reporting This unit 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: • Reusing waste and scrap materials • Safe handling and storage of hazardous goods and substances • Inspecting and maintain tools equipment • Workplace documentation and reporting

4.1 Cleaning and making ready workplace for next work

Cleaning is not just a measure of respect for the workspace, it also removes hazards. Plan to easily and regularly remove trash and debris. Enforce a strict clean up policy throughout the workspace. Keep work areas tidy as well by minimizing the number of wires running around. Extension cords quickly become tripping hazards, and power strips also cause trouble on the ground or as they tumble erratically on a desktop. We suggest you provide access to grounded outlets all along the perimeter of the room and/or dropped from the ceiling for each workbench.

4.1.1 Kinds of Cleaning Solvents

Solutions are homogeneous mixture of two or more components. They can be gaseous, liquid or solid. When we speak of a solution, we usually think of a solid dissolved in water. While water is the most common solvent, other liquids are frequently employed as solvents for certain substances for example wax maybe dissolved in gasoline. The dissolved material in a solution is termed as solute (e.g. Wax) while the dissolving medium is called solvent (e.g. Gasoline). However, the term can be interchanged depending on which substance is of greater amount.

Solvent is a component of a solution that dissolves solute and is usually present in large proportion or amount. It can be classified as polar or non-polar. Polar solvents are solvents which dissolve/are soluble in water; while non-polar solvents are solvents which do not dissolve/are insoluble in water.

Solvents usually used for cleaning in automotive shops are: water, gasoline, kerosene, thinner and detergent soap.

The table below shows the kinds of cleaning solvents based on their solubility in water.

Cleaning Solvents	Solubility in Water	Polar	Nonpolar
a. Water	Soluble	X	
b. Gasoline	Insoluble		X
c. Kerosene	Insoluble		X
d. Thinner	Insoluble		X
e. Detergent soap	Soluble	X	

4.1.2 Properties of Cleaning Solvents

A useful generalization much quoted is that "Like dissolves like". More specifically, high solubility occurs when the molecules of the solute are similar in structure and electrical properties to the molecules of the solvent.

When there is a similarity of electrical properties; e.g. High dipole element between solute and solvent, the solute-solvent attractions are particularly strong. When there is dissimilarity, solute-solvent attractions are weak. For this reason, a polar substance such as H2O usually is a good solvent for a polar substance such as detergent soap but a poor solvent for a non-polar substance such as gasoline.

Uses of Cleaning Solvents

Cleaning Solvents	Uses
1. Gasoline	It is used to wash oil/greasy tools/equipment.
2. Diesel	It is used to wash oil engine, transmission and other parts of the vehicle.
3. Kerosene	It is used to remove dust, grease oil, paint, etc.
4. Thinner	It is used to remove spilled paint on the floor, walls and tools.
5. Soap and water	It is used to wash/clean upholstered furniture such as seats, tables, cabinets, etc.

4.1.3 Occupational Health and Safety Practices in Handling Cleaning Solvents

A great percentage of eye injury and cuts results from a disregard for the simplest of rules in handling cleaning solvents. You should never use compressed air to clean your clothes, hands or body. The pressure could cause the cleaning solvents and dirt particles to penetrate your skin, resulting in infection and /or blood poisoning. Do not use compressed air to clean an object immediately after it has been removed from a hot cleaning tank. First, rinse the cleaning solvents away with water. Do not use carbon tetrachloride as a cleaning solution. The fumes, when inhaled can cause serious internal injury and possibly result in death. When steam-cleaning, place the object to be cleaned on a pallet and wear a face shield and rubber gloves for protection against loose debris.

If a job or cleaning task requires the use of gloves, use the appropriate gloves. Do not for instance use welding gloves when removing an object from a hot tank, or rubber gloves when welding. If you have cut, nicked, or burned yourself, or something has got into your eyes, report immediately to the first-aid person.

Keep all inflammable cleaning solvents in closed tin containers and whenever possible, store them in a separate area.

Cleaning procedures

- ✓ Clean up every time whenever you leave an area, including sweeping the floor.
- ✓ Clean and return all tools to where you got them.
- ✓ Use compressed air sparingly; never aim it at another person or use it to clean hair or clothes.
- ✓ Shut off and unplug machines when cleaning, repairing, or oiling.
- ✓ Never use a rag near moving machinery.
- ✓ Use a brush, hook, or a special tool to remove chips, shavings, etc. From the work area. Never use the hands.
- ✓ Keep fingers clear of the point of operation of machines by using special tools or devices, such as, push sticks, hooks, pliers, etc.
- ✓ Keep the floor around machines clean, dry, and free from trip hazards. Do not allow chips to accumulate.
- ✓ Mop up spills immediately and put a chair or cone over them if they are wet enough to cause someone to slip.

Self-check 4

Direction : Discuss the following questions briefly

1) What are the kinds of Cleaning Solvents?
2) When are the similarity of electrical properties?
3) How do we Uses of Cleaning Solvents?
4) What are the OHS practices in Cleaning Solvents
5) What are the cleaning procedures?

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