

TRADE OF HEAVY VEHICLE MECHANIC

PHASE 2

Module 3

Engine

UNIT: 2

Lubrication System

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1. Learning Outcome

By the end of this unit each apprentice will be able to:

- Define the term 'friction' and give examples of where it is an advantage and a disadvantage on a vehicle
- State the operating principles and function of lubrication systems
- Change the oil and oil filter on an operational 4 cylinder in line diesel engine
- Perform an oil pressure test and interpret the results
- Identify the oil flow path through a 4 cylinder in line engine
- Identify various oil pump types from dismantled engines and perform checks to determine the pumps mechanical condition
- Locate the lubrication data for a given vehicle from a workshop manual

1.1 Key Learning Points

- System components, function and operation, splash, pressure feed full flow/by-pass, wet and dry sump
- Servicing methods, oil change, filters, use of special tools, torque procedures
- Method of performing an oil pressure test. Oil pressure regulation
- Safe use of test equipment
- Relationship between atmospheric, gauge and absolute pressure
- Relevance of oil pressure, high/low
- Lubricating oil properties: quality, viscosity index, index improvers additives, detergents, semi and fully synthetic oils
- Oil pumps types/drives. Checking wear and running clearance of various oil pump types
- Filter systems: full flow, by-pass, combined system, non return valve
- Oil flow diagram for an engine
- Reason for the operation of oil coolers
- Oil levels - consequences of overfilling
- Waste oil' - carcinogenic effect - dermatitis
- Proper draining, storing and safe disposal of oil. 'Oil spillages cause accidents'
- Friction, definition, advantages and disadvantages
- Effect of lubrication on friction
- Relevant lubrication data located and applied from manuals

2. Oil

2.1 Functions of oil

One function of a lubrication system is to reduce friction. Friction occurs between all surfaces in contact. When moving surfaces come together, friction tends to slow them down.

Sometimes that's just what's wanted. Friction can be useful.

But it can also cause serious damage. It can make metal parts so hot they melt and fuse together. When that happens, an engine is said to have seized.



How long an engine lasts depends to a large extent on how well it's lubricated, especially at the points of extreme loading.

So lubrication reduces unwanted friction, and controls it where it is useful.

It reduces wear on moving parts. Clearances fill with oil so that engine parts move or float on layers of oil instead of directly on each other. Much less power is needed to move them and that's a plus.

It helps cool an engine. It collects heat from the engine, then returns to the sump, where it cools.

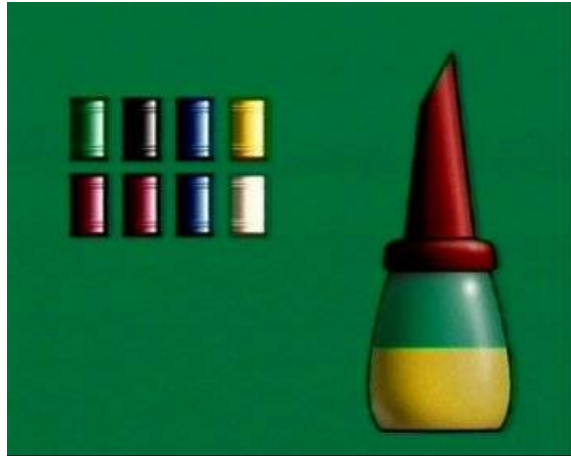
It helps absorb shock loads. A power stroke can suddenly put as much as 2 tonnes force on main bearings. Layers of oil cushion this loading.

Oil is also a cleaning agent. It collects particles of metal and carbon and carries them back to the sump. Larger pieces fall to the bottom.

2.2 Oil additives

Special chemicals called additives are added to the base oil by the oil companies. Different combinations of these additives allow the oil to do different jobs in an engine.

Extreme-pressure additives coat parts with a protective layer so that the oil resists being forced out under heavy load.



Oxidation-inhibitors stop very hot oil combining with oxygen in air to produce a sticky material like tar, which clogs galleries.

Corrosion-inhibitors help stop acids forming that cause corrosion, especially of bearing surfaces.

Anti-foaming agents reduce the effect of oil churning in the crankcase and minimize foaming.

Detergents reduce carbon deposits on parts like piston rings and valves.

Dispersants collect particles that can block the system, separate them from each other and keep them moving. Then they will be removed when the oil is changed.

2.3 Oil Types

Raw crude oil is not a good lubricant. It contains high levels of nitrogen and sulphur compounds as well as wax crystals. Wax and sulphur cause base oil to be less stable, providing targets for heat and chemical degradation that shorten the oil's useful lifespan.

Crude oil is constructed from a wide variety of long chain hydrocarbon molecules which allow oxygen to attack gaps in the molecular structure when the oil gets hot.

When crude oil is refined into base oil, molecules are separated according to their weight which has the effect of separating unwanted materials from desirable ones.

Three hydro-processing methods are used in ultra refining the oil to further enhance its desirable properties.

Hydro-treating is a process of adding hydrogen to the base oil at elevated temperatures in the presence of catalyst. They attach themselves to “gaps” in the oil’s molecular structure blocking oxygen molecules from oxidizing the oil, increasing the useful life of the base oil.

Hydro-treating removes some of the nitrogen and sulphur molecules from the base oil.

Hydro-cracking is a more severe form of hydro-processing. It is done by adding hydrogen to the base oil feed at even higher temperatures and pressures. Oil molecules are reshaped and cracked into smaller molecules leaving fewer gaps for oxygen molecules to attach themselves.

Wax hydro-isomerisation is a third step, which lowers the pour point of the base oil so that it flows well at low temperatures. Wax hydro-isomerisation also removes the majority of remaining sulphur and nitrogen making base oil with exceptional purity and stability. The oil, typically, has no colour.

Aromatics are removed as they increase the tendency of the oil to oxidize and thicken at high temperatures reducing the oil’s viscosity index.

Lubricants are designed so their viscosity is low enough for good cold weather starting, yet high enough to provide adequate film thickness and lubricity at high engine temperatures. The oil’s viscosity has to remain consistent when the engine is hot or when operating in a cold environment. The oil’s ability to cope with this is the viscosity index. A high Viscosity index indicates a small change over the oil’s operating temperature range. A low viscosity index indicates the oil has a poor response to temperature change.

“Synthetic” base oils are chemically engineered base oils. Man made Hydrocarbons called Poly-alpha-olefins or PAO's are a common example of a synthetic base stock.

Synthetic base oil can also be made by removing molecules from Ethylene gas, that accompanies crude as it comes from the ground, and reconstructing them to produce high quality base oil.

2.4 Viscosity

For oil to do all of the work that's expected of it, it must have special properties.

Its viscosity is crucial. Viscosity is a measure of how easily a liquid flows. Low-viscosity liquid is thin and flows easily. High-viscosity liquid is thick and flows slowly.

Lubricating oil must be thin enough to circulate easily between moving parts, but not so thin that it will be forced out from between them. If it is forced out, parts will be left in direct contact and they'll be damaged.



If it's too viscous, it moves too slowly to protect parts, especially in a cold engine.

Oil is also classified by the American Petroleum Institute or API service classification. Oils for spark-ignition engines carry a prefix S, and diesel or compression-ignition engines use C. Some oils have additives that make them suitable for both. Manufacturers recommend which viscosity and API classification is ideal for a particular engine.

2.5 Engine Oil Consumption

All engines use a small amount of oil over time. It gets past the piston rings and valve guide seals and is burned in the combustion chamber. A small amount escapes through the PCV system and a few drops usually managed to seep through a gasket or seal. The question is at what point should one consider oil consumption to be a problem? Any engine that consumes less than a litre of oil every 5000 kms is in excellent mechanical condition. If it uses less than a litre in 2500 kms, it's still in pretty good condition.

But once oil consumption exceeds a litre every 1500 kms, it signals the engine is approaching retirement. Blue smoke in the exhaust or oil consumption on the order of a litre or more every 800 kms indicates serious oil burning problems (usually due to worn or broken piston rings, a cracked piston, or worn valve guides and/or seals).

Sometimes a leaky seal or gasket can make an otherwise good engine use oil. The most frequent leak points are valve cover gaskets, crankshaft end seals and oil pan gaskets. Tightening the valve cover or pan bolts can sometimes stop a leak but usually the only cure is to replace the gasket.

3. Lubrication systems

3.1 Pressure System

Modern vehicle engines use a pressure or force-feed lubrication system where the oil is forced around the engine under pressure. Let's look at gasoline engines first.

Oil won't flow up into the engine by itself so a pump collects it through a pickup tube and a strainer, and forces it through an oil filter, then into passageways in the engine block, called galleries.

The galleries allow oil to be fed to the camshaft bearings, the valve mechanism, and the crankshaft main bearings. Holes drilled in the crankshaft webs allow the main bearings to supply oil to the big-end bearings.

After circulating through the engine, the oil falls back to the sump to cool. This is called a wet-sump lubrication system because the oil is kept in the sump ready for the next time it's used.

Some special engines use a dry sump lubrication system. It uses all of the parts that make up a wet sump system and it lubricates the engine in the same way.

It differs from the wet sump system in the way the oil circulates. In a dry sump system, the oil falls to the bottom of the engine into an oil collection pan. A scavenge pump then pumps it to an oil tank where it is stored until the normal oil pump collects it and pumps it through the filter and engine in the normal way.

Because there is no oil storage sump under the engine, the engine can be mounted much lower than in a wet sump system.

The oil tank can be positioned away from the engine where it can get best cooling. And the amount of oil in the system can be much greater than in the wet sump system.

Diesel engines are lubricated in much the same way as gasoline engines but there are differences.

Diesel engines typically operate at the top end of their power range so their operating temperatures are usually higher than those in similar gasoline engines, so the parts in diesel engines are usually more stressed.

As a result, diesel oils need a different range of properties and are classified differently.

It's common for some diesel engines to use an oil cooler to cool the oil in the engine. The cooler and oil filter are usually on the same mounting on the cylinder block.

3.2 Splash System

Most small 4-stroke gasoline engines use what is called splash lubrication.

On horizontal-crankshaft engines, a dipper on the bottom of the connecting rod scoops up oil from the crankcase for the bearings. In this engine it is also able to splash oil up to the valve mechanism.

Alternatively, an oil slinger can be driven by the camshaft.

A similar system is used in most small vertical-crankshaft engines. Oil is also splashed up to the valve mechanism.

3.3 Environmental factors – Used Lubricants

Introduction:

- Vehicle service centres generate millions of litres' of used motor oil each year.
- If it is not disposed of properly, used motor oil can interfere with the operation of sewer systems and can easily get into our groundwater and streams. In fact, it takes only one litre of used oil to contaminate a million litres of drinking water.
- Re-refining used oil takes only about one-third the energy of refining crude oil to lubricant quality.
- It takes 160 litres of crude oil, but only one litre of used oil, to produce 2 ½ litres of new, high-quality lubricating oil.

Safe environmental disposal of automotive fluids is an essential part of the servicing process. Incorrect disposal is both illegal and dangerous. Different countries use different regulations to administer this process so you should always consult with your local authority as to the specific regulations that apply to you.

As a general rule the following applies:

Illegal Disposal Practices:

- Pouring used oil down a drain.
- Pouring used oil into a storm sewer.
- Tossing used oil on your driveway, street, or the ground
- Disposing of oil in lakes, streams, or wetlands.
- Spreading oil to suppress dust or kill weeds
- Burning oil outdoors or any other heating devices unless the device is approved for the purpose and the premises appropriately licensed.
- Mixing used oil with other substances

Remember:

- Used oil and oil rags have to be collected by an authorized waste disposal company. Contact them for proper procedures in relation to storage and collection facilities.
- Recycling used oil can conserve the earth's natural resources.
- Used oil can be re-refined and purified into high quality motor oil.
- Recycling used oil can save consumers money.

4. Lubrication systems components

4.1 Oil cooler

Engines which operate under severe conditions may use an oil cooler to cool the oil in the engine.

In diesel engines, the oil cooler and oil filter are often on the same mounting, on the cylinder block.

The oil cooler is a heat exchanger. It transfers heat from the oil to coolant from the cooling system. Coolant circulates through tubes in the cooler, and oil fed from the lubrication system surrounds the tubes. As the coolant circulates, heat is removed from the oil.

In another design, the oil cooler is mounted in the air-stream at the front of the vehicle. This type of oil cooler uses the flow of air passing across its fins to cool the oil circulating through it. It is called an oil-to air heat exchanger.



4.2 Oil filters

There are 2 basic oil-filtering systems - full-flow, and by-pass. The full-flow type filters all of the oil before delivering it to the engine. The by-pass type only filters some of the oil.

The full-flow type is the more common. Its filter uses pleated filtering paper in a metal housing, to collect harmful particles.



Normally all oil goes through the filter before it gets to the engine, but if the filter clogs up, it can starve an engine of oil.

As a safety measure, full-flow filters have a bypass valve. If the filter clogs, this valve opens and directs unfiltered oil to the engine. Dirty oil is better than none at all.

Most oil-filters on diesel engines are larger than those on similar gasoline engines, and some diesel engines have 2 oil filters.

Diesel engines produce more carbon particles than gasoline engines, so the oil filter can have a full-flow element to trap larger impurities, and a bypass element to collect sludge and carbon soot.

In a by-pass system, the bypass element filters only some of the oil from the pump by tapping an oil line into an oil passage. It collects finer particles than a full-flow filter. After this oil is filtered, it goes back to the sump.

4.3 Oil indicators

If a lubrication system fails it's serious, so it's crucial to know its working. If oil pressure falls too low, a pressure sensor in a gallery can light up a warning light, or register on a gauge.

Low oil pressure can mean a lack of oil. It may have leaked away, or it may have been burned.



This can be caused by worn piston rings which let oil into the combustion chamber.

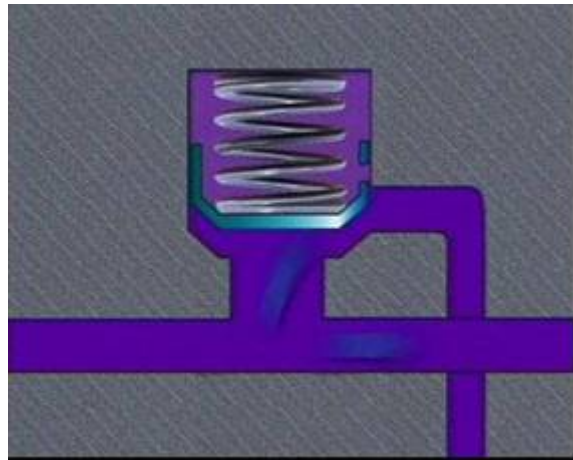
Some engines even use an automatic cut-out that turns off the engine if oil pressure falls too low.

Too little oil in the engine is a problem but so is too much. The crankshaft can whip it into foam, and cause leaks by flooding the seals..

Of course, the simplest indicator of oil level is still the dip stick.

4.4 Oil pressure relief valve

A normal pump is capable of delivering more oil than an engine needs. It's a safety measure to ensure the engine is never starved for oil. As the pump rotates, and engine speed increases, the volume of oil delivered also increases. The fixed clearances between the moving parts of the engine prevent oil escaping back to the sump, and pressure builds up in the system.



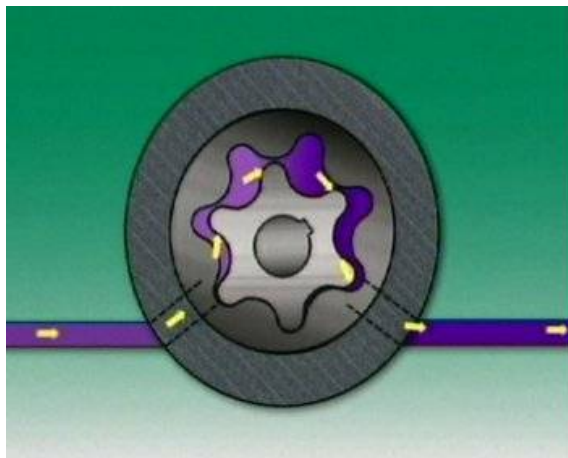
An oil pressure relief valve stops excess pressure developing. It's like a controlled leak, releasing just enough oil back to the sump to regulate the pressure of the whole system.

4.5 Oil pump

Oil pumps may be driven from the camshaft or the crankshaft.

In a rotor-type oil pump, an inner rotor drives an outer one. As they turn, the volume between them increases. This larger volume lowers the pressure at the pump inlet.

Outside atmospheric pressure is then higher. This forces oil into the pump, and it fills the spaces between the rotor lobes.



As the lobes of the inner rotor move into the spaces in the outer rotor, oil is squeezed out through the outlet.

The crescent pump uses a similar principle. It is mounted on the front of the cylinder block.

The inner gear is on the end of the crankshaft which then drives the pump directly. An external toothed gear meshes with this inner one. Some gear teeth are meshed but others are separated by the crescent-shaped part of the pump housing.

The increasing volume between gear teeth causes pressure to fall. Oil is then taken through the intake port, and carried around between the gears and crescent, then discharged to the outlet port.

Similarly in a geared oil pump, the driving gear meshes with a second gear. As both gears turn, their teeth separate, creating a low pressure area. Higher atmospheric pressure outside forces oil up into the inlet. The spaces between the teeth fill with oil. The gears rotate, and carry oil around the chamber. The teeth mesh again, and oil is forced from the outlet toward the oil filter.

4.6 Pickup Tube

Between the sump and oil pump is a pickup tube with a flat cup and a strainer immersed in the oil. The strainer stops large particles of dirt and carbon entering the pump and damaging it. The pickup tube leads to the inlet of the oil pump, on the low pressure side of the pump.



4.7 Spurt holes and galleries

Pistons, rings and pins are lubricated by oil thrown onto the cylinder walls from the connecting rod bearings.

Some connecting rods have oil spurt holes. These holes are positioned to receive oil from similar holes in the crankshaft. Oil can then spurt out at the point in the engine cycle when the largest area of cylinder wall is exposed. It lubricates the walls and gudgeon pin, and also cools the underside of the piston.

Oil feeds to the cylinder head, and through a gallery to the camshaft bearings and valve-train. As well as lubricating these moving parts, it also gathers heat from the engine so its temperature keeps rising.

Finally it drains back to the sump to cool, and start again.



4.8 Sump

The sump is bolted to the engine under the crankcase.

It is a reservoir, or storage container, for the engine lubricating oil, and a collector for oil returning from the engine lubricating system.

The sump can be formed as a thin sheet metal pressing, and shaped to ensure that oil will return to its deepest section.

The oil pickup tube and strainer are located in this deep section to ensure they stay submerged in oil, and to prevent air being drawn into the oil pump.



Some high performance vehicles have a baffle tray fitted to prevent churning of the oil by the rotation of the crankshaft.

Baffles prevent oil from surging away from the pickup during cornering, braking and accelerating.

The sump's large external surface area helps heat transfer from the oil to the outside air.

In some designs, the sump is an aluminum alloy casting with fins and ribs to assist in this heat transfer.



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