CPL Theory
Aircraft Systems (CSYA)

CSYA 3 – Oil System

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3. Disclaimer

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THE FIVE FUNCTIONS OF OIL

Functions of Oil

- Piston engines require oil for the following functions:

1. **Lubrication**
2. **Cooling**
3. **Cleaning**
4. **Sealing**
5. **Protection**

Functions of Oil - Lubrication

- Oil lubricates the moving parts of the engine so they can move smoothly
- When one metal surface is moving over another, they are actually separated by a thin, unbroken film of oil

Unbroken film of oil

- Without this, there would be lots of friction which would:

1. Generate high temperatures

2. Wear the metal surfaces

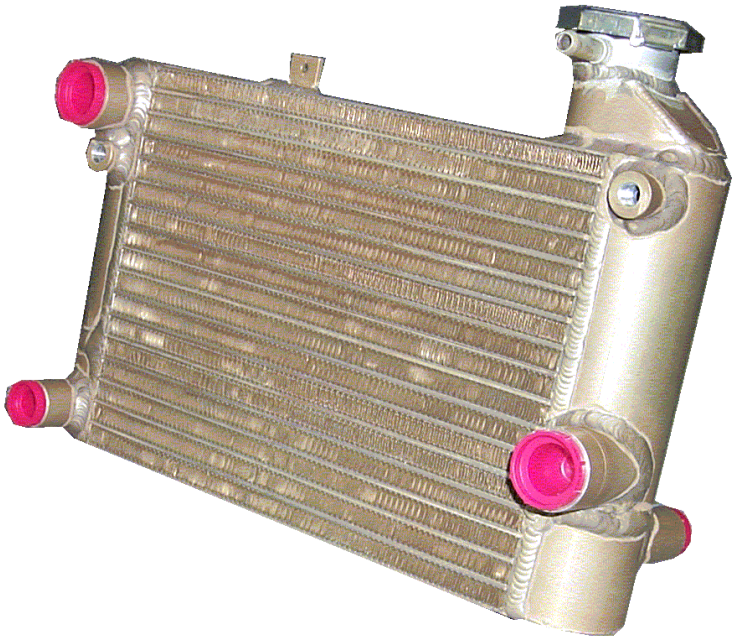
3. Possibly cause mechanical failure

Functions of Oil - Lubrication

- This image shows the consequences of high friction between metal on metal, where a connecting rod has pushed through the cylinder casing

Functions of Oil - Cooling

- The combustion process causes the pistons to become hot
- Oil is splashed or sprayed onto them for cooling
- This oil is then carried away and cooled via the oil cooler, thereby assisting in the cooling of an engine



Functions of Oil - Cleaning

- Oil circulating through an engine can pick up and carry away dirt and other foreign material
- This reduces wear on moving parts of the engine
- The contaminants are then removed from the oil via the oil filter

Functions of Oil - Sealing

- Oil provides a seal between the cylinder walls, the pistons and the piston rings

- This traps the pressure from the combustion process inside the combustion chamber so that none of the explosive power from the power stroke is lost

- Oil also cushions engine components subject to high loads, such as the bearings at either end of the connecting rod. This reduces the mechanical shock on them.

Functions of Oil - Protection

- Steel surfaces such as the cylinder walls or crankshaft are subject to rust or corrosion when uncovered in air

- A thin layer of oil covering these surfaces will prevent the oxygen reacting with the metal, reducing corrosion

PROPERTIES OF OIL

Properties of Oil

- In order to carry out its 5 functions, oil needs to have the following properties:

1. Viscosity

2. High “flash point”

3. Chemically stable

Properties of Oil - Viscosity

- Viscosity of oil refers to its resistance to flow

COLD OIL has high viscosity – it will be thick and sticky

HOT OIL has low viscosity – it will be thin and runny

- As the engine heats up, the oil will become less and less viscous and flows more freely
- Oil must be sufficiently viscous to lubricate, seal and protect, but thin enough to flow into small clearance areas to reach all required engine parts
- Oil that is sufficiently over a wide operating range of engine temperatures is known as a **multi-grade oil**

Properties of Oil – Flash Point & Stability

- Oil is a flammable substance
- The oil must have a sufficiently high “flash point” or ignition point to ensure that it will not vaporise or catch fire whilst operating inside engines
- Oil must also be chemically stable
- It must remain in its current chemical state and keep its characteristics (viscosity etc.) over the operating range of temperatures and pressures

TYPES OF OIL

Types of Oil

- Different types of oils are designed for different operating conditions
- They are identifiable by the colour and markings on the bottles

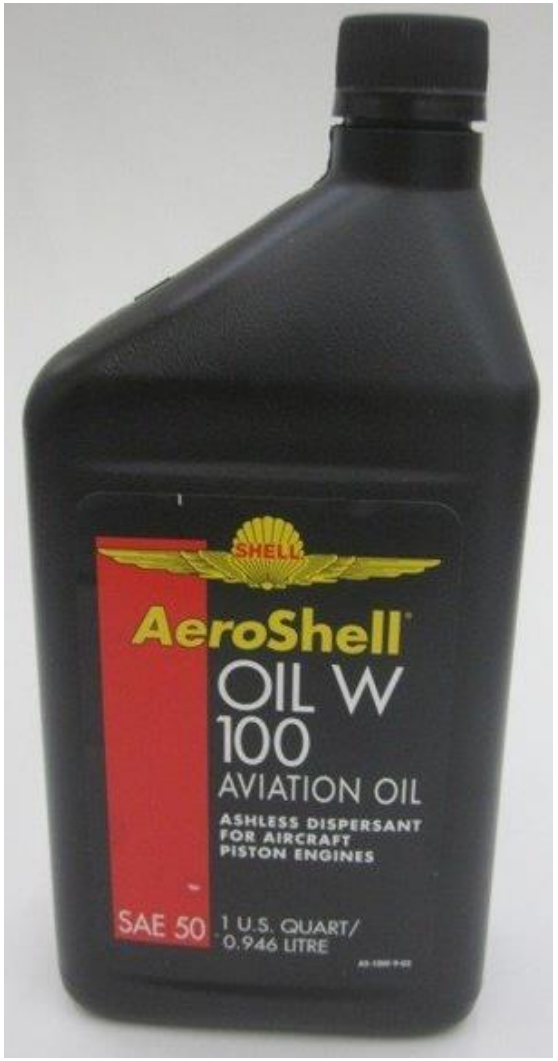
- The markings usually consist of a commercial aviation number or a Society of Automotive Engineers (SAE) rating
- W100 is the same as an SAE 50 which refers to the viscosity rating (it will be a 50-weight oil when hot)
- Use only the correct type of oil as directed by the pilot's operating handbook and **do not use turbine (jet) oil** in piston engines

Types of Oil – Straight Mineral Oil (Red Band)

- Mineral Oils are susceptible to oxidisation and the formation of a ‘sludge’ capable of clogging oil screens and filters

- For these reasons, this type of oil has largely been replaced for normal aircraft operations

- However, it is normal to use Red Band oil for the first 50 hours of an engine’s life or straight after major overhaul, as it encourages the working surfaces or the engine to rub together and form a good seal



Types of Oil – Ashless Dispersant

- AD is the most common oil used today

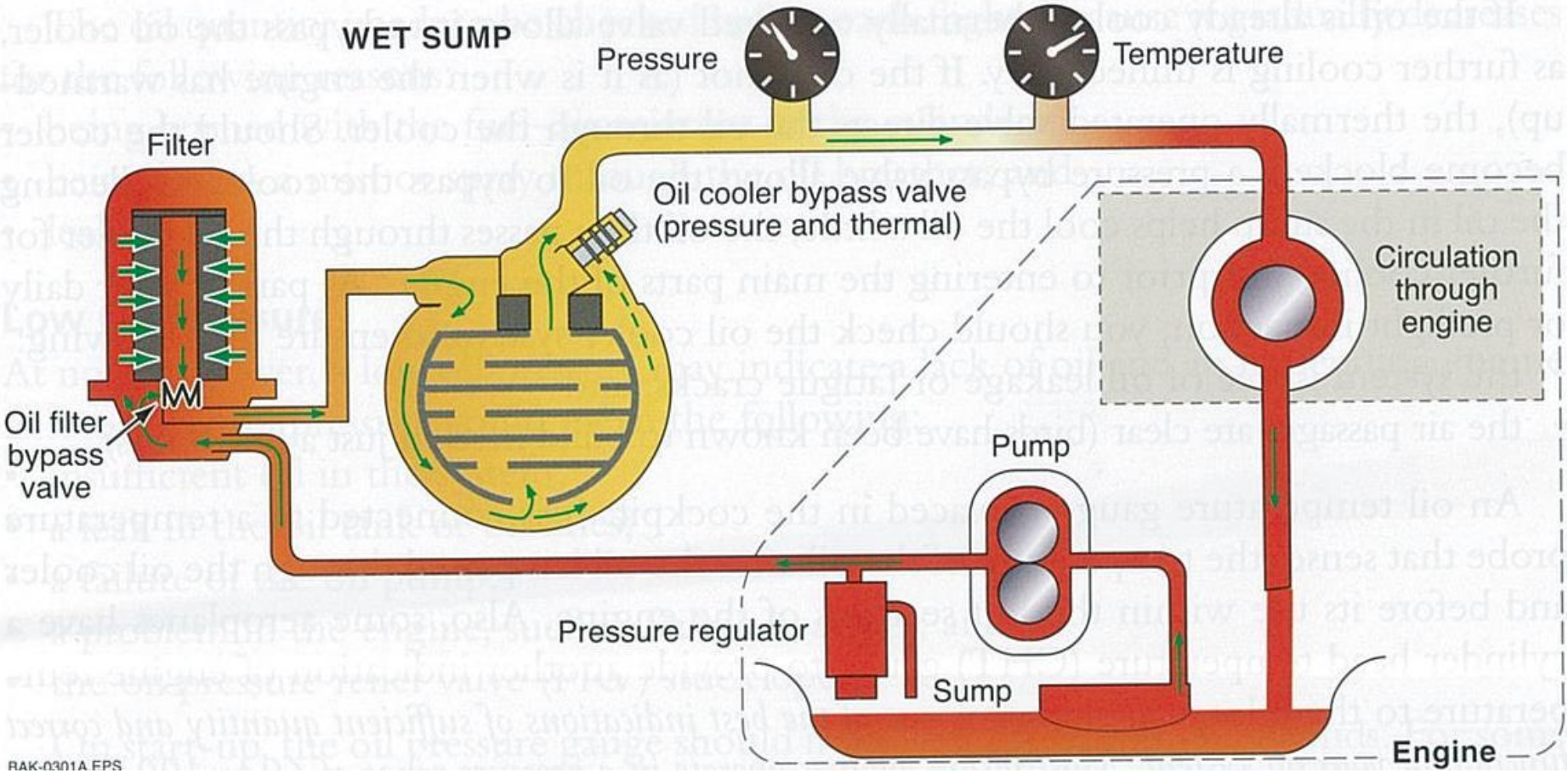
- It is actually mineral oil but has dispersant additives which cause the components of the ‘sludge’ to repel each other and remain separate until they are collected by the oil filter

Types of Oil – Synthetic Oil

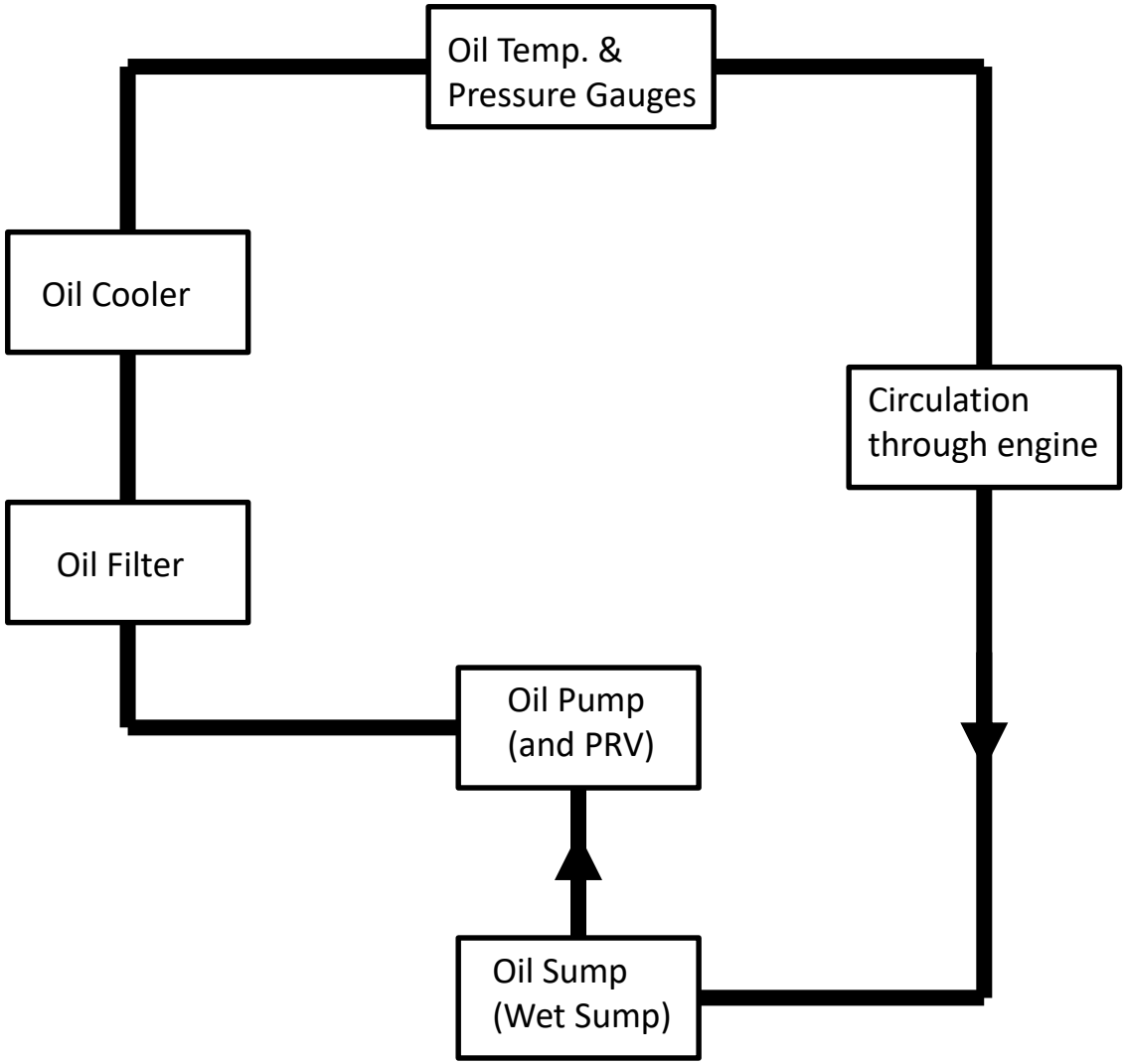
- Largely used in turbine aircraft and is superior to mineral oils for lubrication at high operating temperatures and high altitude
- However, it is not commonly used in piston engines as it is about 8 times more expensive than mineral oil
- Note that oils within their basic categories can be mixed i.e. mineral oils can be mixed with other mineral oils
- However, it is not advisable to mix mineral and synthetic oils
- Motor oil must not be used in an aero engine

OIL SYSTEM COMPONENTS

Oil System Diagram



Oil System Diagram



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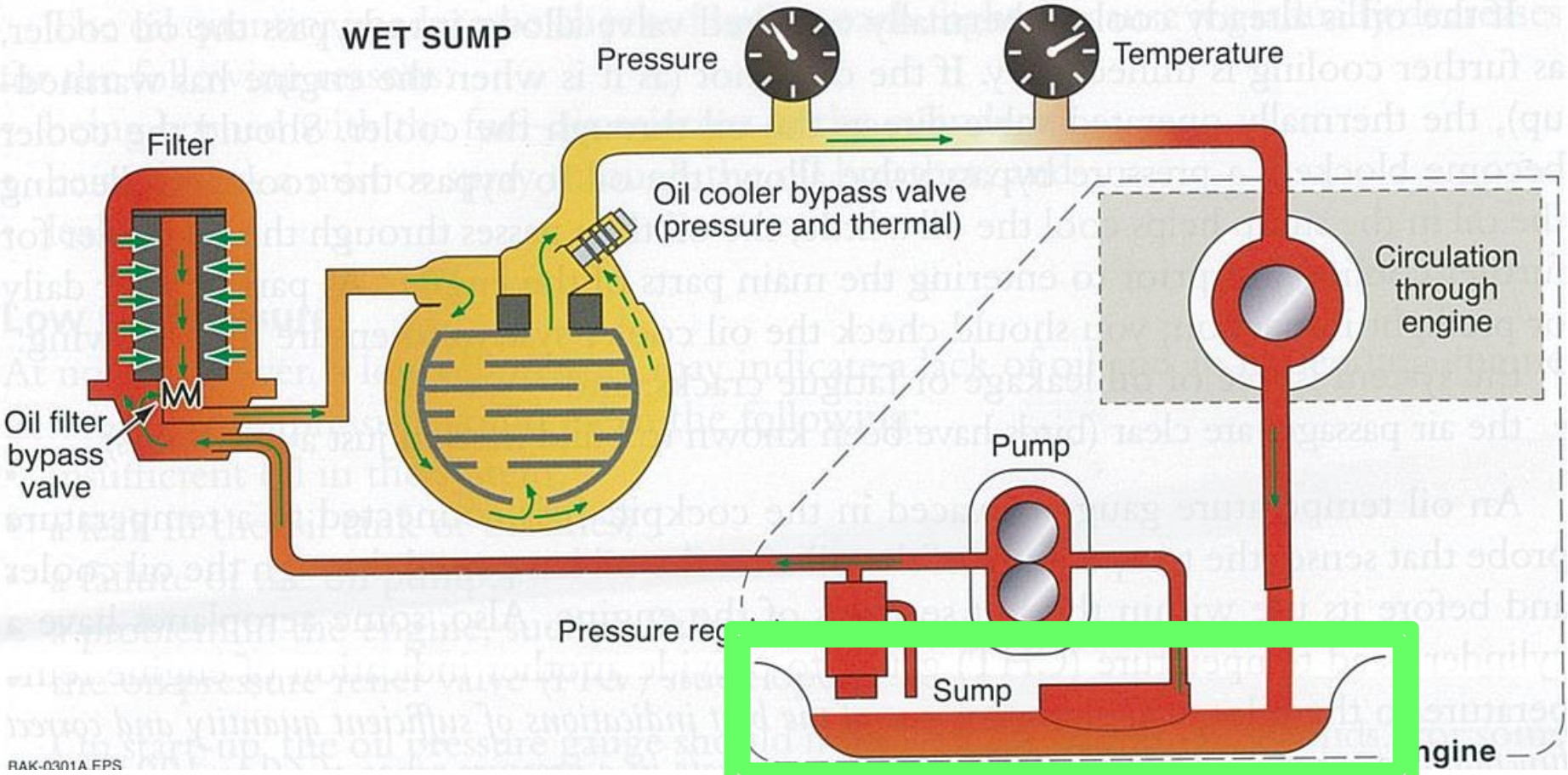
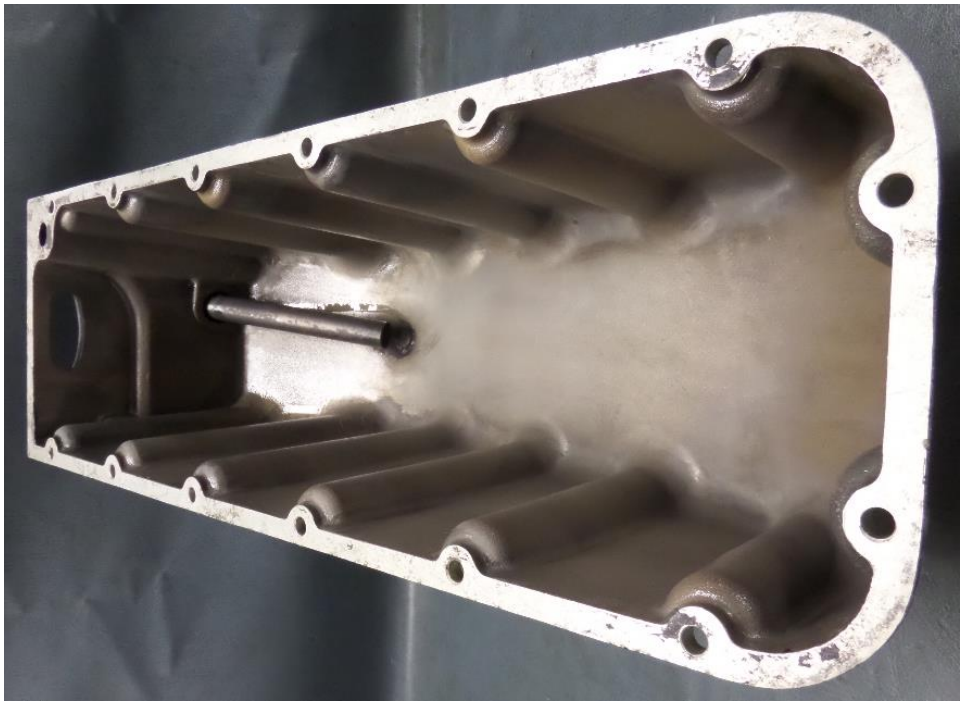


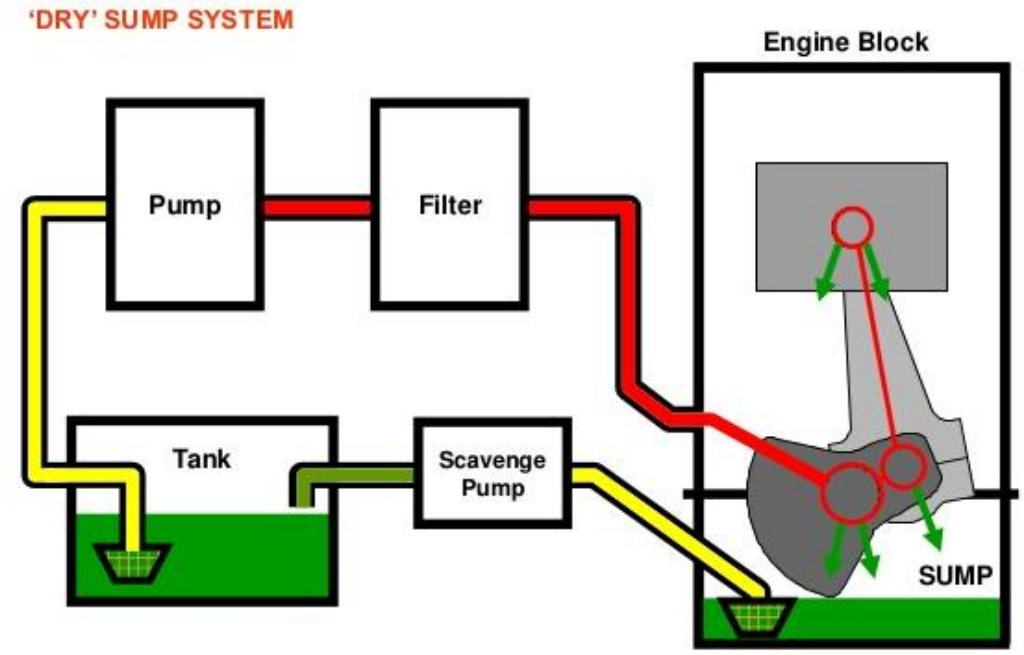
Oil Sump

- After doing its work in the engine, the oil returns (usually via gravity) to a sump which is a reservoir below the engine
- This is called a **wet sump** which most light aircraft (and all motor vehicles) have
- From the sump, the oil is then re-circulated through the system



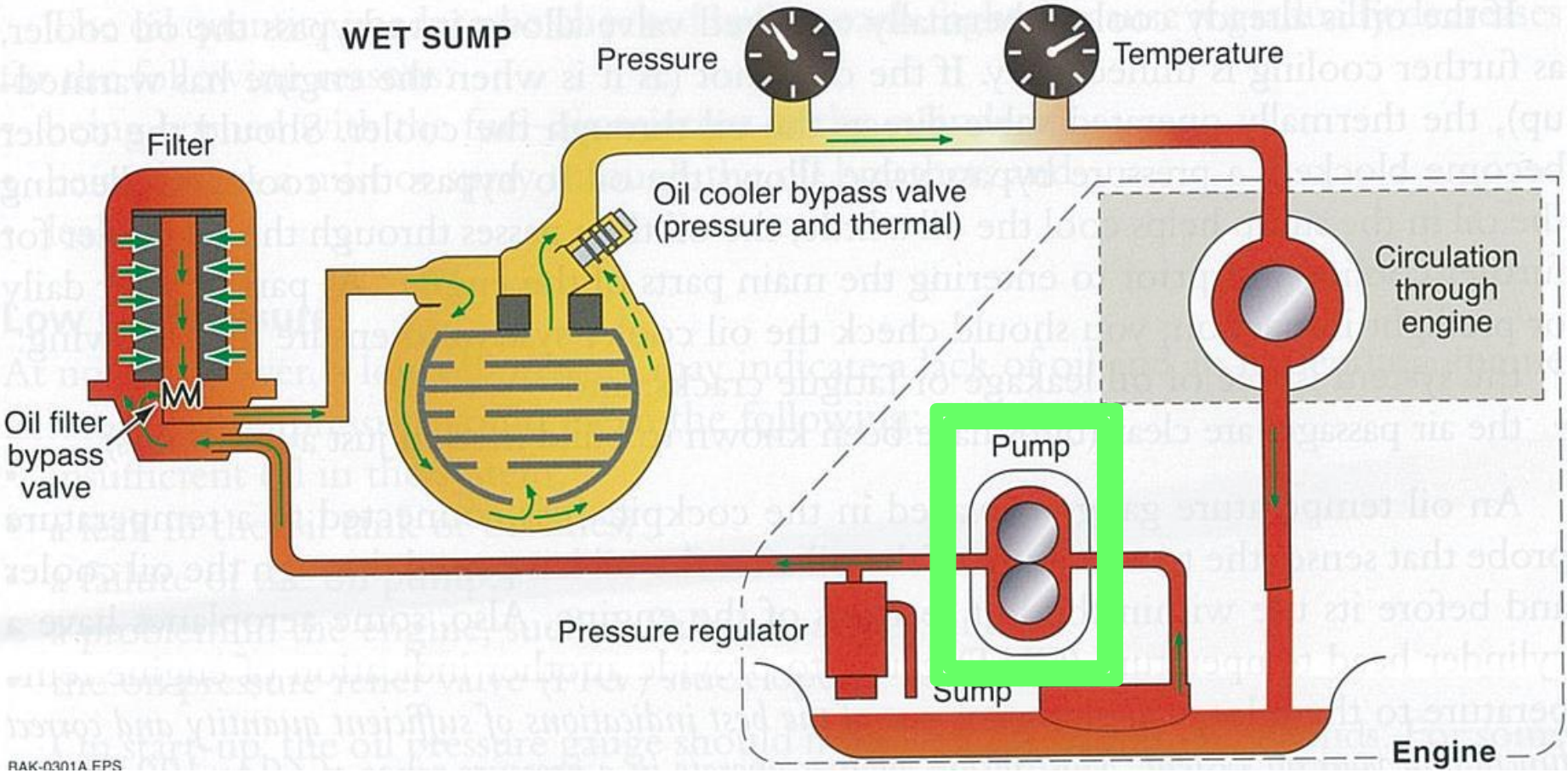
Oil Sump

- The main problem with a wet sump is that during high angles of bank and inverted manoeuvres oil will drain from the sump
- For this reason, aircraft fitted with a wet sump system are not permitted to conduct inverted manoeuvres for extended periods of time, it at all
- Most aerobatic aircraft will be fitted with a **dry sump**



- A dry sump system involves a **scavenge pump** which pumps the oil out of the sump and into a separate, **external tank**
- Scavenge pumps are of the same design as the oil pump but have a **larger capacity**
- The external tank is enclosed and thus oil can flow normally during any manoeuvres

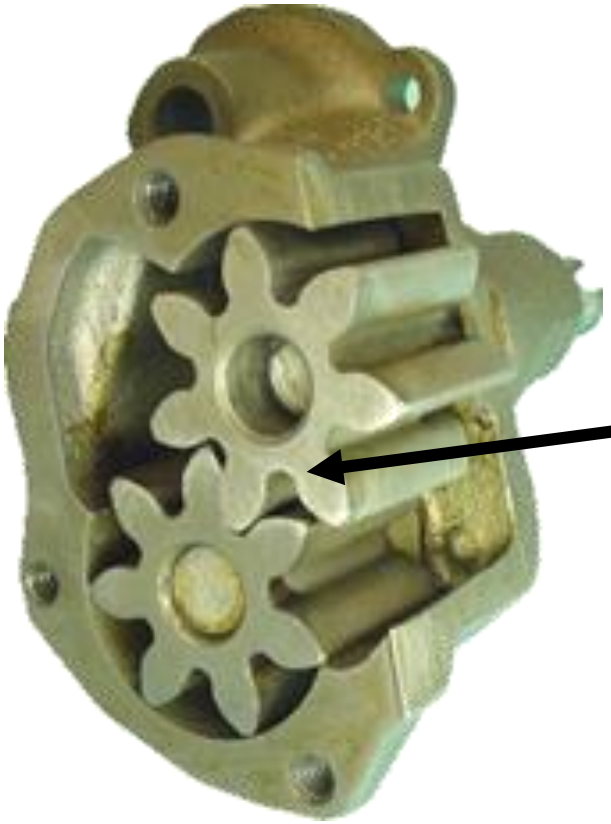
Oil System Diagram



Oil Pump

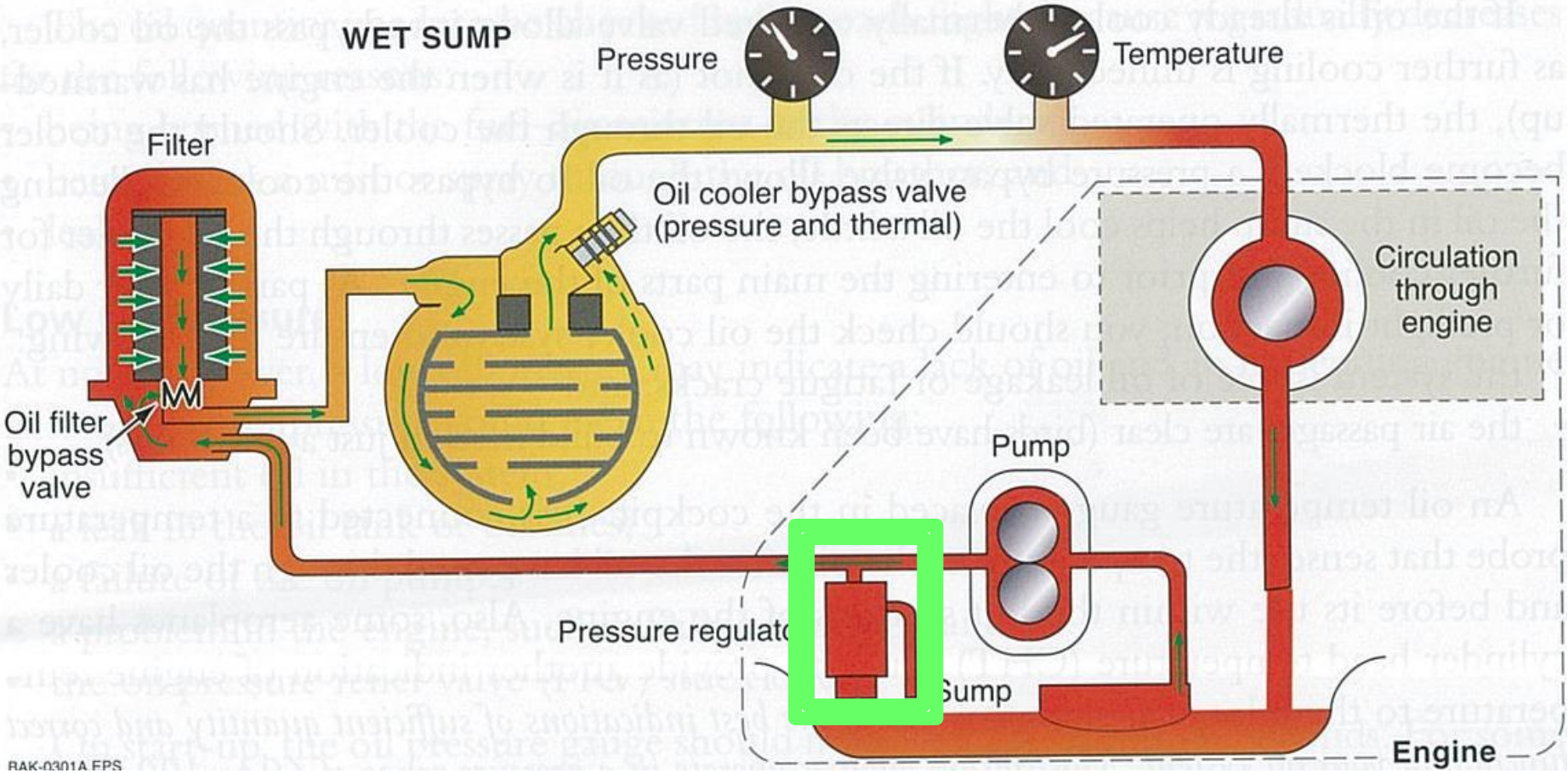
- The oil pump moves oil around the oil system (from the sump to the engine)

- It is a gear type pump driven by the accessory gearbox (gears at the back of the engine)



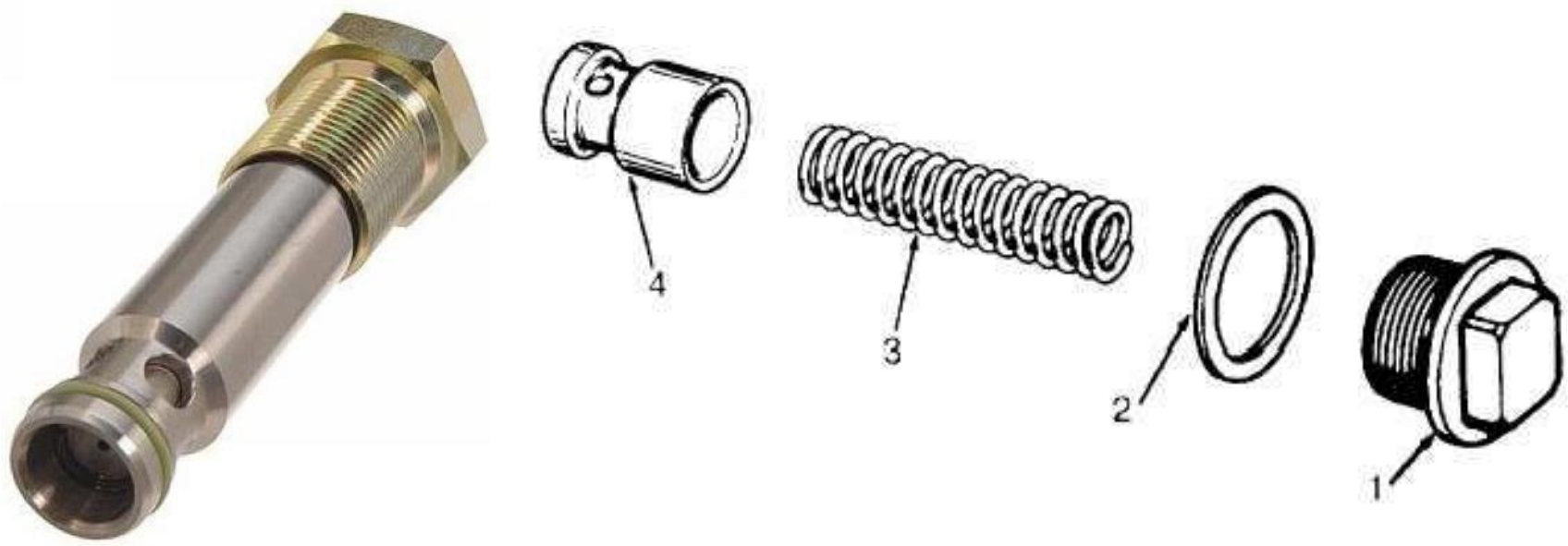
Oil is passed through a gearbox to accelerate its flow

Oil System Diagram



Oil Pressure Regulator

- Within the oil system is a pressure regulator
- It is also known as a spring loaded Pressure Relief Valve (PRV)
- If the pressure set on the PRV is exceeded, the valve will open and relieve the pressure by allowing excess oil to return to the sump
- This maintains the oil pressure within the correct limits



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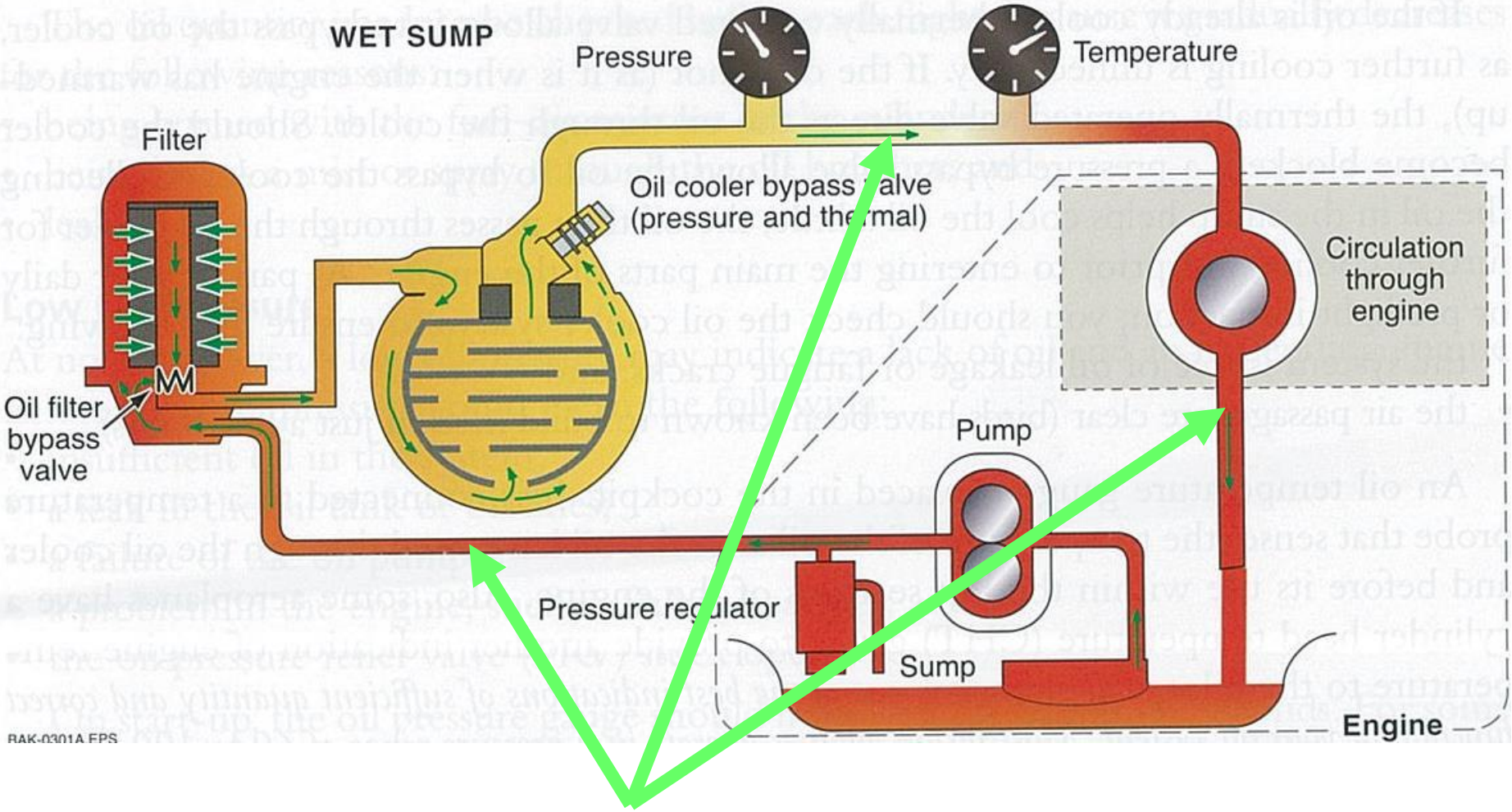
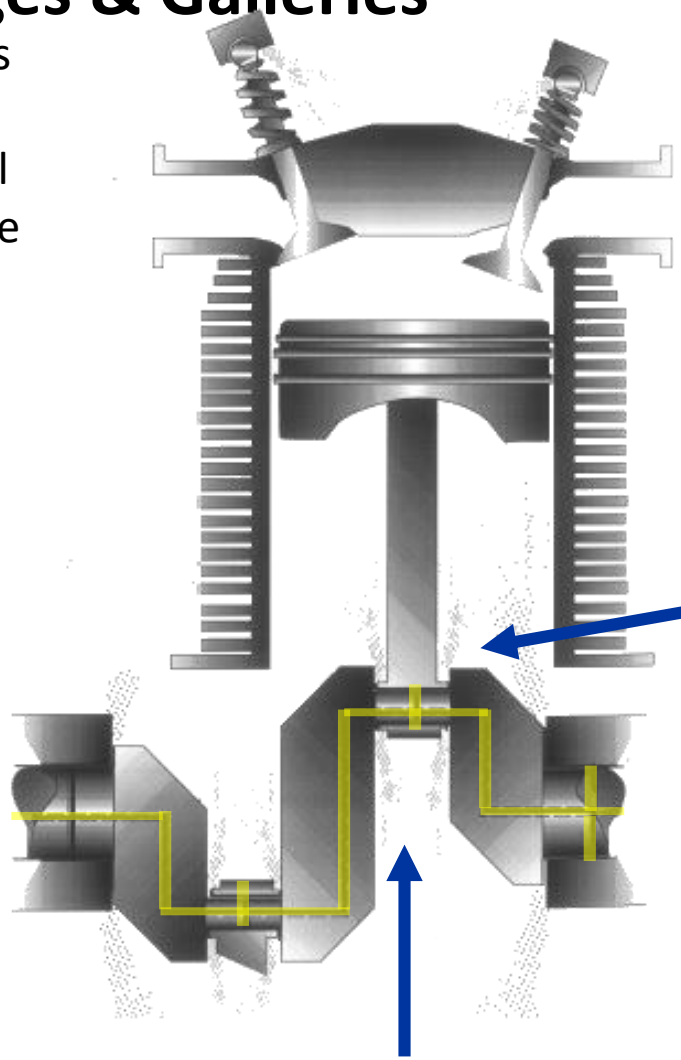


Oil Lines, Passages & Galleries

- These are the avenues through which oil is moved through the oil system and around the various engine components

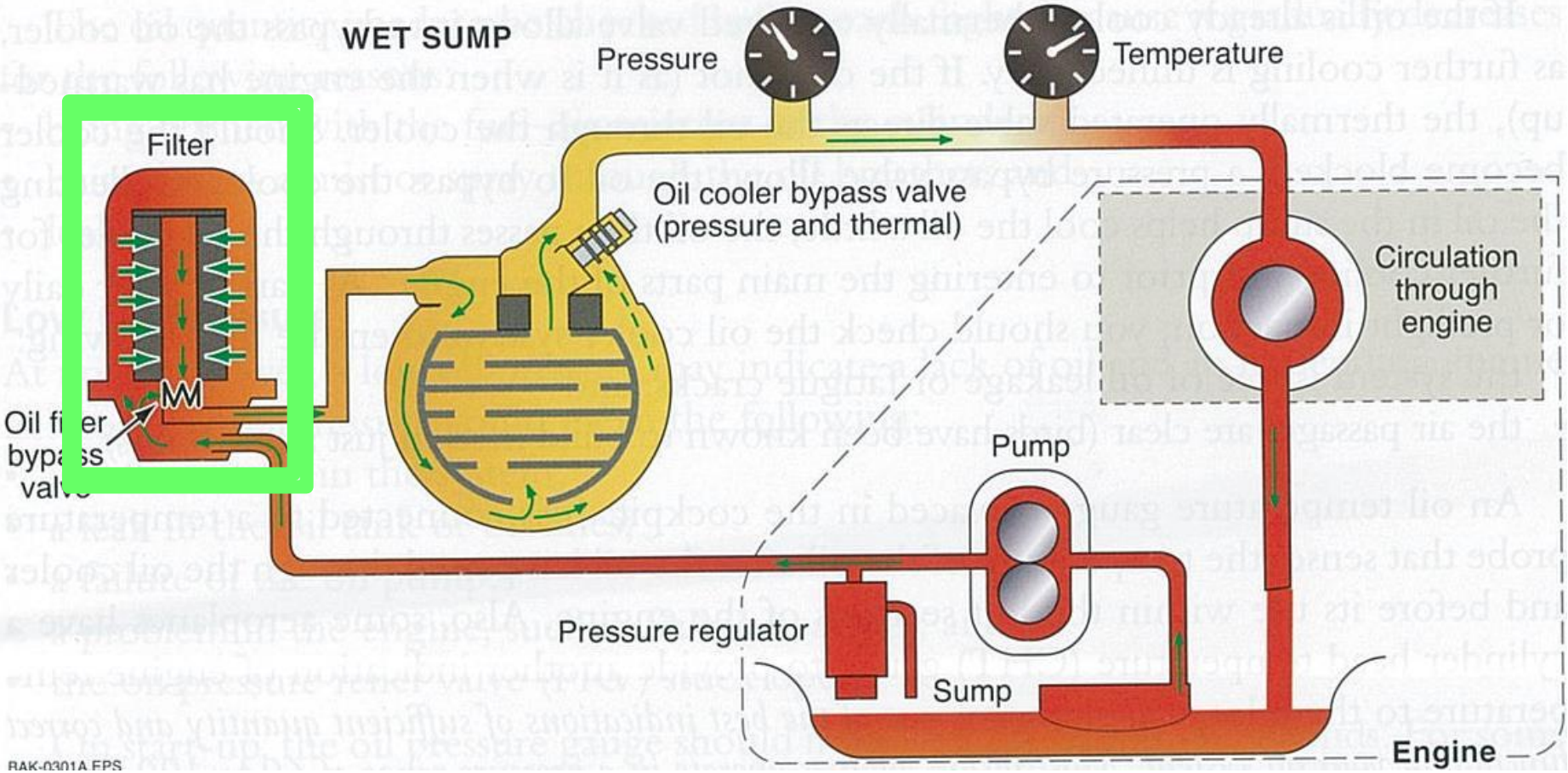


The main bearings are lubricated by oil which is pumped through channels inside the crankshaft.

The oil leaves the bearings as a fine spray and the crankshaft rotation flings it into the cylinders.

It then drains back to the oil sump located below the cylinder.

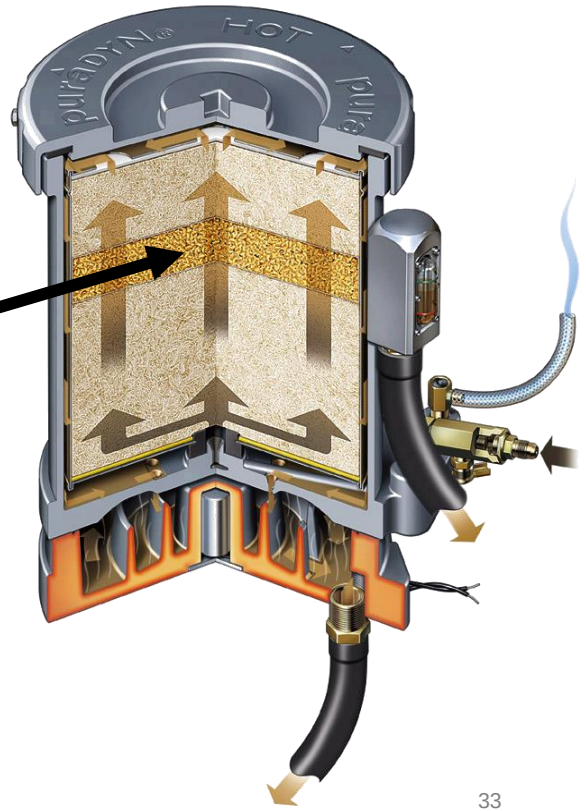
Oil System Diagram



Oil Filter

- Before entering the engine, the oil passes through an oil filter
- This removes any contaminants such as dirt or carbon particles
- The oil filter has a bypass valve so that if it becomes blocked, contaminated oil may still circulate
- Dirty and contaminated oil is preferable to no oil at all

Oil is passed through a pad where impurities are removed



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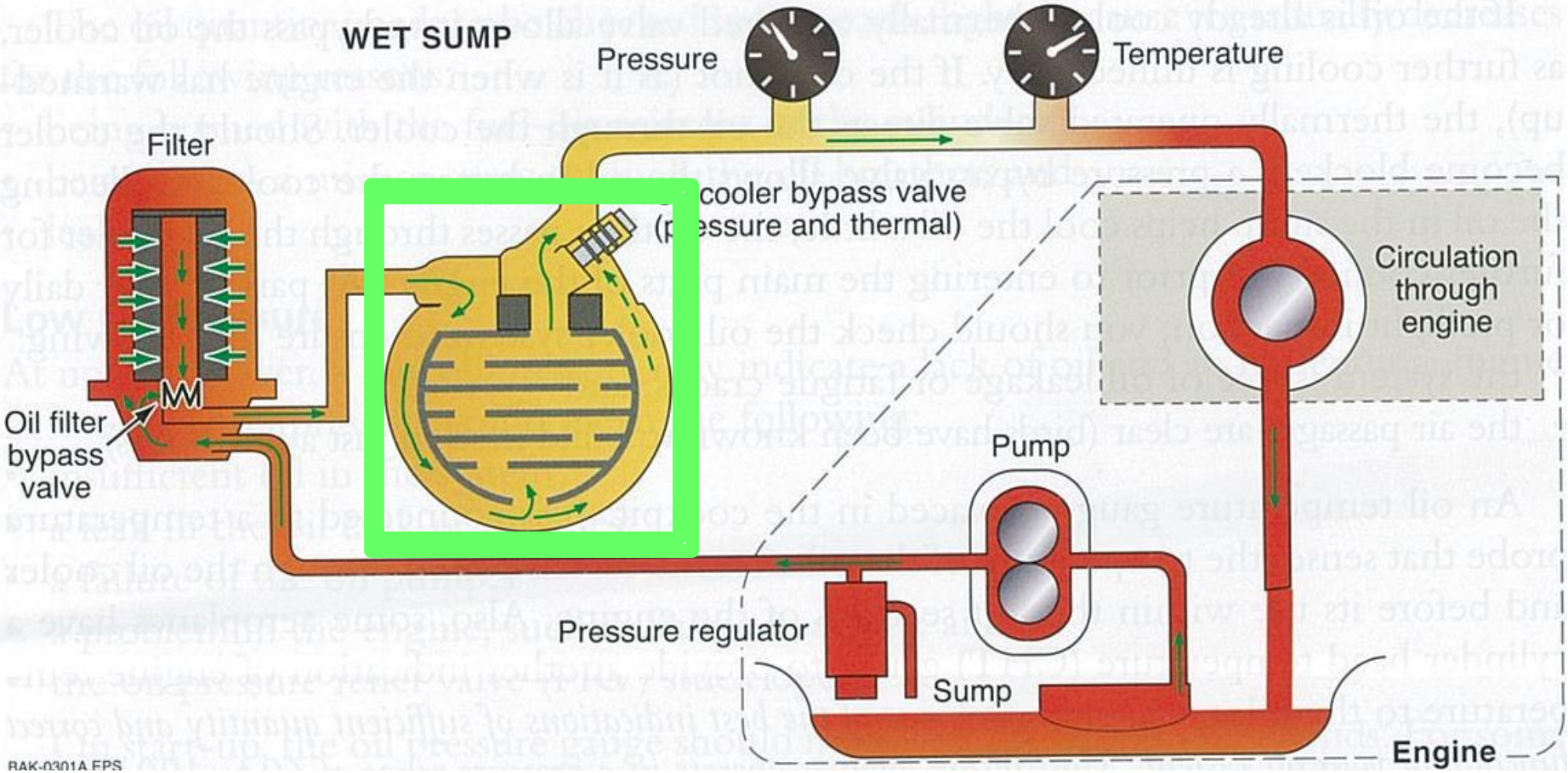
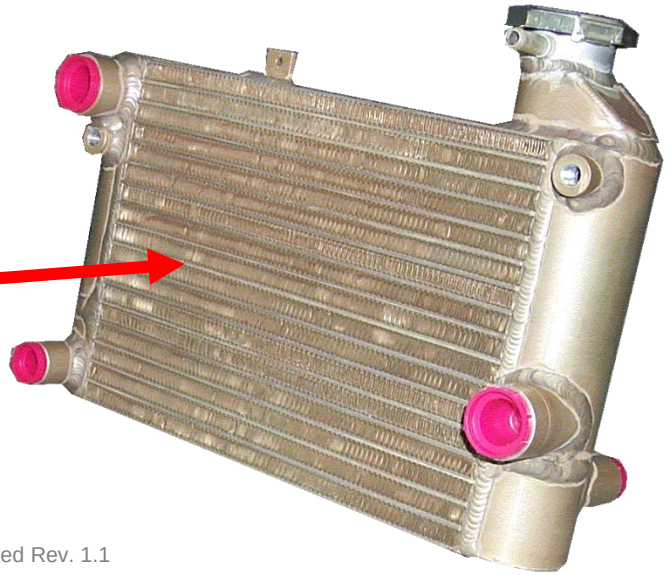


Oil Cooler

- Oil cools slightly in the sump, but it also passes through a cooler before re-entering the engine
- The oil cooler is fitted with both a thermal and pressure bypass system
- If the oil is already cool, the thermal bypass will allow oil to skip the oil cooler and go straight to the engine
- Should the oil cooler become blocked, the cooler bypass valve will allow oil to still circulate

Atmospheric air flows onto the exposed surface



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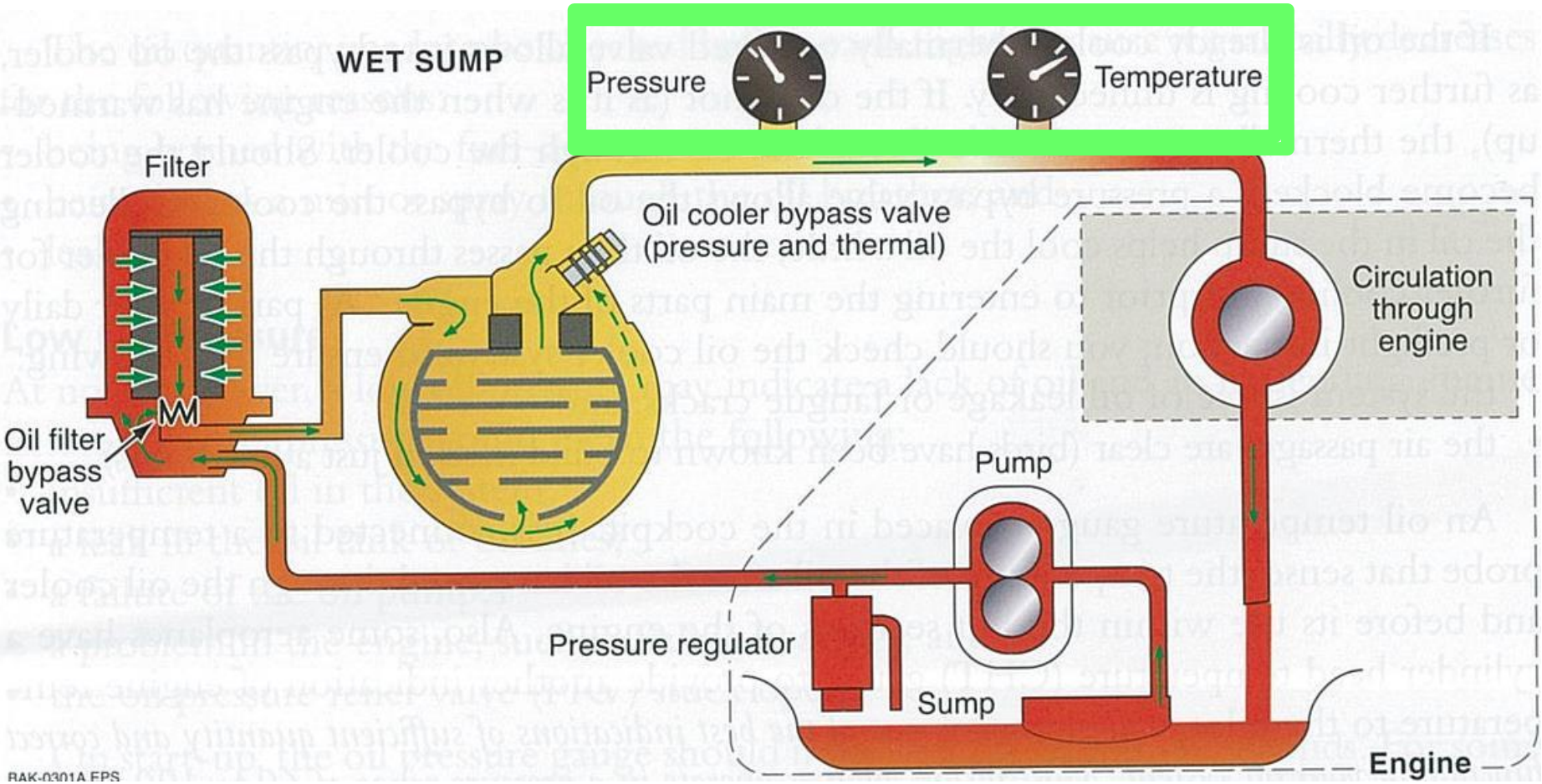


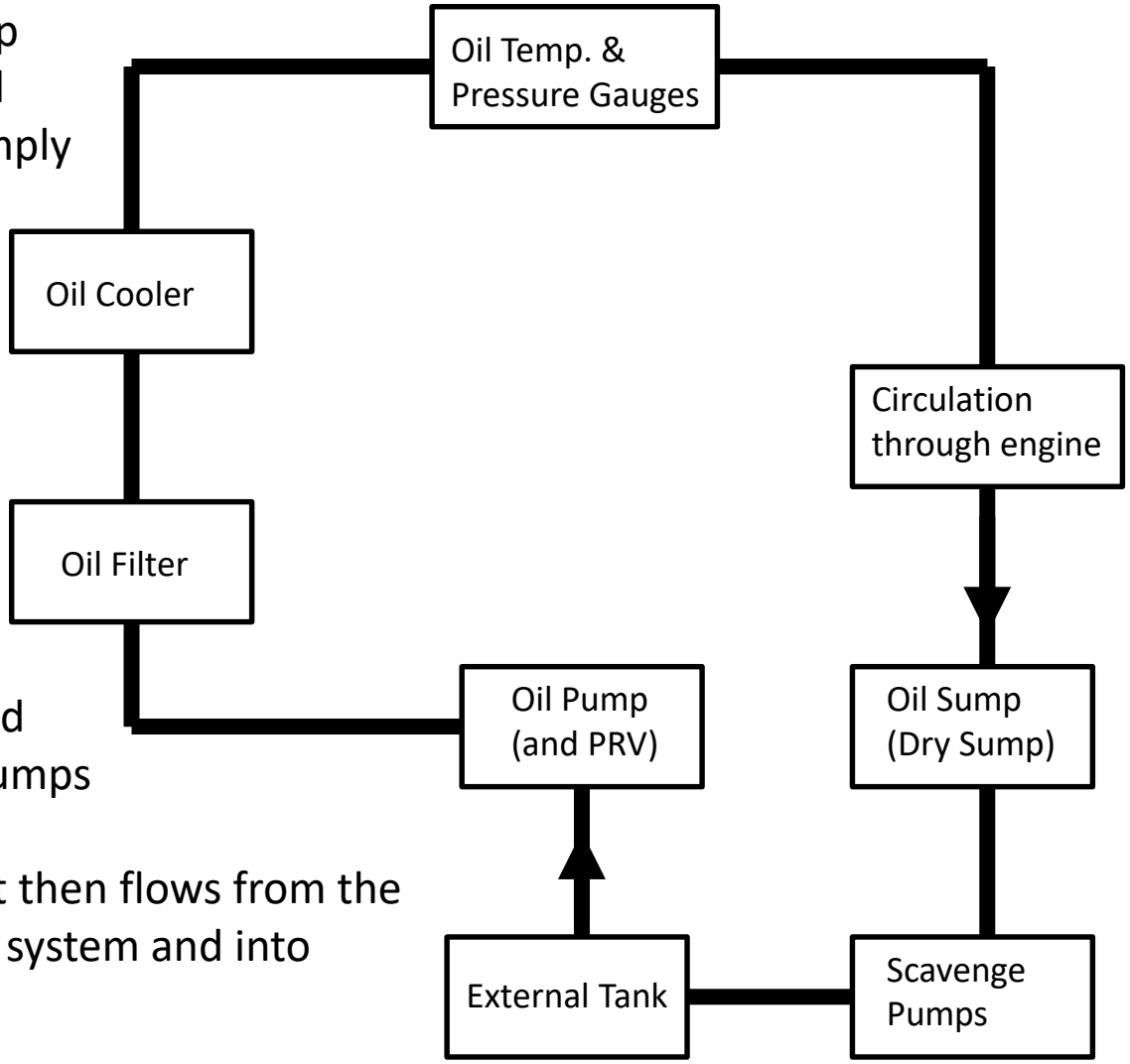
Oil Temperature & Pressure Gauges

- The sensors for these gauges are located after the oil filter and cooler but before oil enters the engine

- This gives the pilot the best indication of the temperature and pressure of the oil doing work in the engine

Dry Sump System

- If an aircraft with a Wet Sump Oil System rolled inverted, all the oil in the sump would simply fall out, meaning the aircraft would rapidly lose oil
- To fix this, many aerobatic aircraft are fitted with a Dry Sump Oil System
- Instead of oil being stored in the sump, oil is pumped into and stored in an enclosed external tank via scavenge pumps
- When oil needs to be used, it then flows from the external tank through the oil system and into the engine as normal



REPLENISHING OIL

Replenishing Oil

- Before each flight, you should check the oil quantity via the dipstick and add oil
- Oil quantity gradually decreases from:
  - Being burned with the fuel/air mixture in the cylinders
  - Being lost as a mist or spray through the oil breather
  - Leaks
- Oil quantity is measured in quarts
- The C172 has a maximum oil quantity of 8 quarts and a minimum of 5 quarts
- **CAE Oxford has a company-ops minimum of 6 quarts**

Replenishing Oil

- Oil quantity can be checked on a dipstick, which is calibrated to show the quantity in quarts
- If the oil level is too low, then the oil will overheat and oil pressure will be too low
- If the oil level is too high, excess oil may be forced out through various parts of the engine

Tips for checking oil quantity:

- The oil can take approximately 10 minutes to return to the sump and only then can a true reading be taken
- When replacing the dipstick, care must be taken not to over-tighten the cap

Replenishing Oil

IF YOU REQUIRE OIL

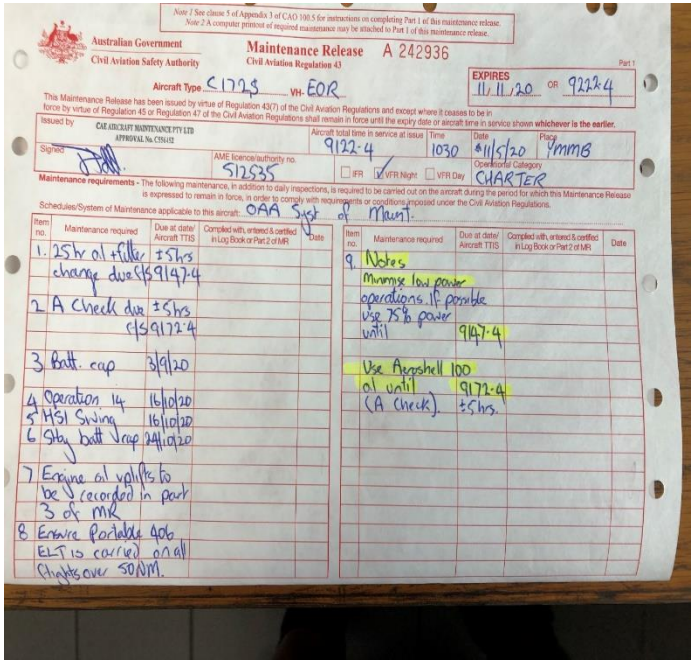
1- Speak with your instructor (ignore if you hold a PPL and are solo flying)

2- Sign out oil release form with dispatch and collect oil

3- Check correct grade of oil (Check Maintenance release if red band oil (Aeroshell 100) is to be added, otherwise W100)

4- Fill in oil added on Maintenance Release (use left/right engine for twin aircraft)

5- Add the oil to the aircraft using a funnel. If you haven't seen this done before, please get your instructor to show you first



CHANGING OIL

Changing Oil

- Since the same oil in an engine is continually circulated, over a period of time it will become contaminated (the oil filter cannot clean it perfectly)
- Chemical changes such as oxidation and absorption of water will also occur
- Consequently, oil must be changed regularly as part of the maintenance schedule

OIL PRESSURE & TEMPERATURE

Oil Pressure & Temperature

- An oil temperature and pressure gauge is fitted so the pilot can monitor the health of the engine

- There will be maximum and minimum operating values and the pilot must be careful to ensure that the oil temperature and pressure remains within these limits

Oil Temperature:

- Maximum - 118° Celsius (245° Farenheit)
- Normal Operating Range – 100° F to 245° F

Oil Pressure:

- Maximum – 115 psi
- Minimum – 20 psi
- Normal Operating Range – 50 to 90 psi

Low Oil Pressure Indication

- A lack of oil in the system e.g. due to a leak in the system or insufficient oil quantity before start-up
- A failure of the oil pump
- The Oil Pressure Relief Valve stuck open

On start up, the oil pressure should rise within 30 seconds. If it does not, then oil may not be circulating properly and the engine should be shut down to save damage

High Oil Temperature Indication

- A lack of oil in the system e.g. due to a leak in the system or insufficient oil quantity before start-up

- Excessive cylinder head temperatures

If a low oil pressure is seen in conjunction with a high oil temperature, the most likely cause is that there is a lack of oil in the system. The best action is to:

- **reduce power**
- **lower the nose to increase airspeed**
- **open cowl flaps (if fitted)**
- **land ASAP as an engine failure is likely**

Other Indications

Low Oil Pressure & Normal Oil Temperature:

- This could simply mean the oil pressure gauge is faulty
- Still treat with caution – continuously monitor the gauges!

Low Oil Temperature:

- This would be normal just after engine start
- As the engine warms up, the oil temperature will rise
- Ensure that oil temperature is in the green arc before take-off

High Oil Pressure:

- The Oil Pressure Relief Valve should ensure that the oil does not reach an unacceptably high pressure
- This would likely cause part of the oil system to fail and render the whole system inoperative