

CHAPTER 5

JET AIRCRAFT ENGINE LUBRICATION SYSTEMS

The increased complexity of aircraft engines has added to the requirements for proper lubrication. Jet engines require lubrication to prevent friction from reducing the engines' efficiency. Oil is the lifeblood of the aircraft engine. If the oil supply to the bearings stops, the lubricating films break down and cause scoring, seizing, and burning between moving parts. Fortunately, the engine oil pump and oil system are dependable. Like the heart and circulatory system of the human body, they quietly perform their function so well we forget their importance.

LEARNING OBJECTIVES

When you have completed this chapter, you will be able to do the following:

1. Discuss aircraft engine lubricants.
2. Describe the functions of jet engine oils.
3. Identify the two main types of lubrication systems.
4. Describe the engine oil system.
5. Discuss engine lubrication system maintenance procedures.
6. Explain the goals and requirements of the Joint Oil Analysis Program (JOAP).

LUBRICANTS

The primary purpose of any lubricant is to reduce friction caused by metal-to-metal contact. Lubricating oils provide a film that permits surfaces to glide over one another with less friction. Therefore, lubrication is essential to prevent wear in mechanical devices where surfaces rub together.

The Navy uses many types of lubricants. The selection of the proper lubricant depends on the design of the equipment and the operating conditions. Maintenance instruction manuals (MIMs) or maintenance requirements cards (MRCs) list the type of lubricant required for specific aircraft maintenance tasks. With an understanding of the different types of lubricants, their characteristics, and purposes, you will know why we must use the proper lubricant. Using the wrong type of lubricant, mixing different types, or lubricating improperly can cause extra maintenance man-hours, part failures, and accidents.

NOTE

You should consult the applicable technical instructions for the grade number or Military Specifications (MILSPEC) of oil recommended for use in an engine. Reciprocating engines use, MIL-PRF-2105-E, W-120, or E-120 oil, which is not compatible with the turbojet engine.

Types of Lubricants

Lubricants are classified according to their source—animal, vegetable, petroleum, mineral, or synthetic. Animal oils are not suitable lubricants for internal-combustion engines. They form fatty acids, which cause corrosion when exposed to high temperatures. Vegetable oils have good lubricating qualities, but break down (they change in chemical structure) after long periods of operation in internal-combustion engines. Mineral-base lubricants are usually divided into three

groups—solids, semisolids, and liquids. Petroleum-based oils (for example, MIL-PRF-6081 grade) were used in early jet engines. This oil was distributed in two grades—1010 for normal use and 1005 for extremely low temperatures. A MIL-PRF 6081 grade 1010 is still used as preservation oil in fuel systems.

The types of lubricants used in the engines of today are different from the lubricants used years ago. As the power output of jet engines increased, aircraft were able to fly higher. The operation of jet engines at these higher, colder altitudes and higher engine temperatures created greater demands on lubricating oils. This, in turn, required the development of synthetic lubricants that could withstand these higher bearing temperatures.

MIL-PRF-7808 was the first synthetic oil developed to meet these demands. Today, most jet engines use synthetic-based oil, MIL-PRF-23699. These two oils are completely compatible and may be mixed when necessary. However, certain 23699 characteristics are downgraded in proportion to the quantity of 7808 oil, if mixed. Synthetic oils are based on acids and other chemicals; therefore, they are not compatible with the mineral- or petroleum-based oils.

NOTE

You are probably more familiar with the Society of Automotive Engineers (SAE) numbers for grading viscosity. If you want a comparison between the two systems, take the last 3 numbers for the Saybolt system, divide by 2, and round to the nearest multiple of 10. For example, 1065 has an SAE rating of 30.

FUNCTIONS OF JET ENGINE OILS

Lubricating oils must perform three basic functions in a jet engine: (1) lubrication, (2) cooling, and (3) cleaning.

1. Lubrication. Oils should have the following characteristics to lubricate properly:
 - It must be of low enough viscosity to flow readily between closely fitted, rapidly moving parts. It must also have a high enough viscosity to prevent metal-to-metal wear.
 - It must not break down under high temperatures and pressures.
 - It must have a low enough pour point to flow readily when starting under extremely low temperatures.
 - It must have a high enough flash and fire point so it does not burn or vaporize under high heat.
 - It should not form and deposit excessive amounts of carbon, varnish, or gum deposits.
2. Cooling. Lubricating oil must cool moving parts by carrying heat away from gears and bearings. This is an important function considering the many parts located next to burners or turbine wheels, where temperatures are over 1700 degrees Fahrenheit (F). Liquid lubricants cool by pumping or spraying oil on or around bearings or gears. The oil absorbs the heat and later dissipates it through oil coolers.
3. Cleaning. Another major function of lubricating oil is cleaning. Oil carries dirt, small carbon and metal particles, and gum and varnish to filters. This has become increasingly important with the higher compression ratios, engine speeds, operating temperatures, and closer tolerances between parts in newer engines.

Designations of Lubricating Oils

Lubricating oils used by the Navy have a classification number, which shows the grade and intended use of the oil. Aircraft engine lubricating oils are given a four-digit grade number, such as 1065. The Navy and the Air Force use the Saybolt scale for designating the viscosity of oil. The designation consists of four digits. The first digit designates the use of the oil; the 1 indicates aviation engine lubrication. The last three digits give the viscosity using the Saybolt scale. Synthetic oils use military specification numbers for references as shown in *Table 5-1*.

Table 5-1 — Classification of Lubricating Oils

NATO Number	MILSPEC & Grade	Use
O-133	MIL-O-6081 Gr. 1010	Early turbine engine lube oil. (Fuel system preservative and oil).
O-148	MIL-PRF-7808	Three centistoke turbine engine synthetic lubricating oil.
O-156	MIL-PRF-23699	Five centistoke turbine engine and gearbox oil.

Contamination of Lubricating Oils

Contaminated oil in the lubricating system of an engine can be disastrous to engine operation. Lubricating oils can be contaminated through operational conditions (dusty or sandy places, or high operating temperatures), faulty maintenance practices, and part failures.

An example of harsh operational contamination is carbon. Carbon forms when oil evaporates, especially where heat is concentrated; for example, in the bearing compartments near hot turbine sections. This carbon eventually breaks off and circulates through the engine lubricating system. The pieces of carbon are usually not hard enough or large enough to cause failure of the pumps. However, they may be large enough to clog small filters or nozzles. The presence of sand, dirt, and metallic particles in the lube system is another source of operational contamination.

Faulty maintenance practices that contaminate lubricating systems include using the wrong type of or mixing oils, and improper servicing. The lube system parts of an engine are made of materials selected based upon the type of oil to be used. Synthetic oils attack the common rubber materials used in the O-rings, seals, and gaskets of lubrication systems that are supposed to use mineral-based oil. This attack causes the material to soften, swell, and lose its ability to seal properly. This condition allows the oil to leak from the system.

The contamination of oil by rust is likely caused by water in the oil system. There is also contamination from storage containers or servicing equipment. Over time, rust in the lube system will eventually discolor the bearings. Ordinary rust will leave a red discoloration on the bearing elements, and black iron oxides will leave a black indication. These rust particles are not large enough to cause pump failure.

The contamination of oil by engine fuel can result from a ruptured fuel-oil cooler. Because the fuel system operates at a higher pressure than the lube system, the flow will be into the oil supply. The presence of fuel in the oil will cause oil dilution. It also changes the oil properties so the oil cannot cool and lubricate the bearings properly.

Another serious type of contamination is the oil itself. Synthetic oil will cloud or form other contaminants if stored too long. This is why there is a shelf life for all synthetic oils. Never use over-aged oil. Follow the applicable instruction for shelf life of synthetic oil (it is usually 6 months) to prevent problems.

Lubricating Greases and Their Properties

Another type of lubricant Aviation Machinist's Mate (AD) should be familiar with is grease. Grease is used on bearings, outside the engine lubricating system, on control arms and linkages, and on actuators. The most important requirements of greases are as follows:

- **Stability.** It must be free from bleeding (separation of oils), oxidation, and changes in consistency during periods of storage and use.
- **Non-corrosiveness.** The lubricant must not chemically attack the various metals and other material it comes in contact with.
- **Water resistance.** In some cases, grease that is insoluble in water is required. In other cases, the grease must be resistant only to weathering or washing.
- **Satisfactory performance in use.** The grease must perform satisfactorily in the equipment and under the conditions it was intended.

Properties of greases vary with the type of soap used in manufacturing. Military specifications specify the operating conditions or applications. *Table 5-2* contains information on some of the most frequently used greases.

LUBRICATION SYSTEMS

Oil systems used in jet engines are relatively simple in design and operation, but their function is important. The principal purposes of the oil system are the same as those covered under lubricating oils—to provide an adequate supply of clean oil to bearings and gears at the right pressure and temperature, to remove heat from the engine, and to remove contaminants from the system and deposit them in the filters.

The ability of the oil to lubricate correctly depends upon its temperature and pressure. If the oil is too hot, it will not have enough viscosity. If it is too cold, the oil will resist movement between the parts and flow too slowly for proper lubrication. If the oil pressure is too low, not enough oil will be supplied to the bearing for proper cooling. If the pressure is too high, it may cause high-speed antifriction bearings to skid and not roll properly.

It would be impossible to cover all the different parts of every type of engine oil system in use today. Therefore, this text presents a representative sample of various parts common to different types of oil systems.

Table 5-2 — Common Military Lubricants and Their Uses

<i>TITLE AND SPECIFICATION</i>	<i>RECOMMENDED TEMPERATURE RANGE</i>	<i>GENERAL COMPOSITION</i>	<i>INTENDED USE</i>
MIL-G-23827 [Grease, Aircraft, Synthetic, Extreme Pressure]	-100 to 250 °F (-73 to 121 °C)	Thickening agent, low temperature synthetic oils, or mixture EP additive	Actuator screws, gears, controls, rolling-element bearings, general instrument use
MIL-G-21164 [Grease, Aircraft, Synthetic, Molybdenum Disulfide]	-100 to 250 °F (-73 to 121 °C)	Similar to MIL-G-23827 plus molybdenum disulfide	Sliding steel-on-steel heavily loaded hinges, rolling element bearing where specified
MIL-G-81322 [Grease, Aircraft, General Purpose, Wide Temperature Range]	-65 to 350 °F (-54 to 177 °C)	Thickening agent and synthetic hydrocarbon; has cleanliness requirements	O-rings, certain splines, ball and roller bearing assemblies, primarily wheel bearings in internal brake assemblies, and where compatibility with rubber is required
MIL-G-4343 [Grease, Pneumatic System]	-65 to 200 °F (-54 to 93 °C)	Thickening agent and blend of silicone and diester	Rubber-to-metal lubrication: pneumatic and oxygen systems
MIL-G-25537 [Grease, Helicopter Oscillating Bearing]	-65 to 160 °F (-54 to 71 °C)	Thickening agent and mineral oil	Lubrication of bearings having oscillating motion of small amplitude
MIL-G-6032 [Grease, Plug Valve, Gasoline and Oil Resistant]	32 to 200 °F (0 to 93 °C)	Thickening agent, vegetable oils, glycerols, and/or polyesters	Pump bearings, valves, and fittings where specified for fuel resistance
MIL-G-27617 [Grease, Aircraft Fuel and Oil Resistant]	-30 to 400 °F (-34 to 204 °C)	Thickening agent and fluorocarbon or fluorosilicone	Tapered plug and oxygen system valves; certain fuel system components; anti-seize
MIL-G-25013 [Grease, Ball and Roller Bearing, Extreme High Temp]	-100 to 450 °F (-73 to 232 °C)	Thickening agent and silicone fluid	Ball and roller bearing lubrication

Types of Lubrication Systems

Engines use a wet-sump, dry-sump, or a combination of both as lubricating systems. Wet-sump engines store the lubricating oil in the engine or gearbox. Dry-sump engines use an external tank

mounted on the engine or somewhere in the aircraft structure near the engine. You should know the similarity and operation of these systems (*Figures 5-1 and 5-2*).

Wet-Sump System

Engines needing a limited supply of oil and cooling can use a wet-sump type (*Figure 5-1*). The reservoir for the wet-sump system is either the accessory gear case or a sump mounted to the bottom of the accessory gear case. This system is similar to your car's engine. In the wet-sump oil system, the gearbox provides space for foaming and heat expansion because the oil level only partly fills the casing. Deaerators, in the gearbox, remove oil from the air and vent the air outside.

The main disadvantages of a wet-sump system are as follows:

- The oil supply is limited by the sump capacity.
- It is hard to cool the oil. Oil temperatures are higher because the oil is continuously subjected to the engine temperature.
- The system is not adaptable to unusual flight altitudes, since the oil supply would flood the engine.

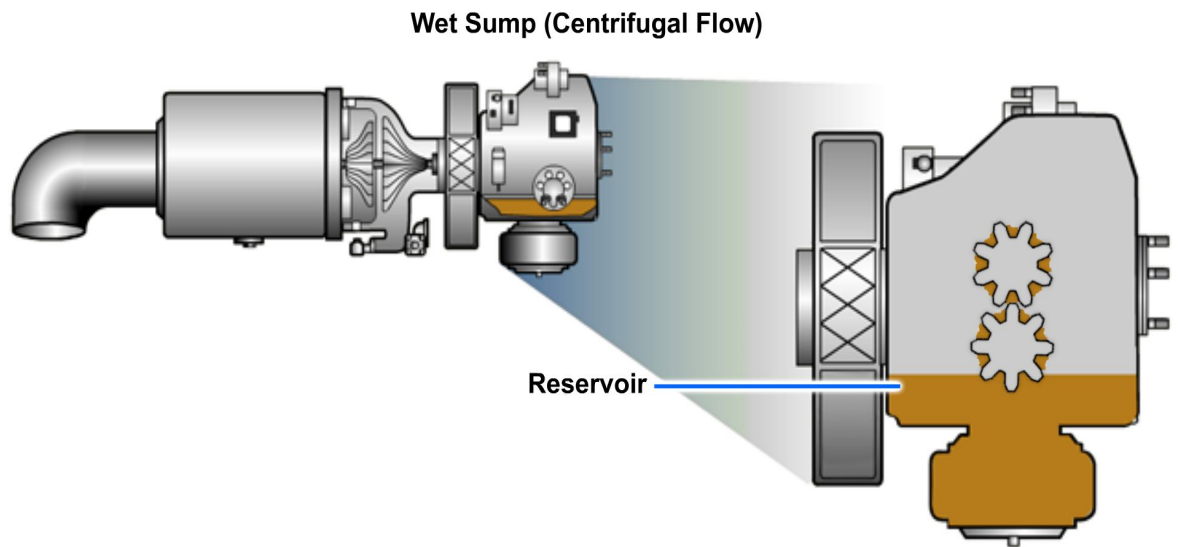


Figure 5-1 — Wet-sump lubrication system.

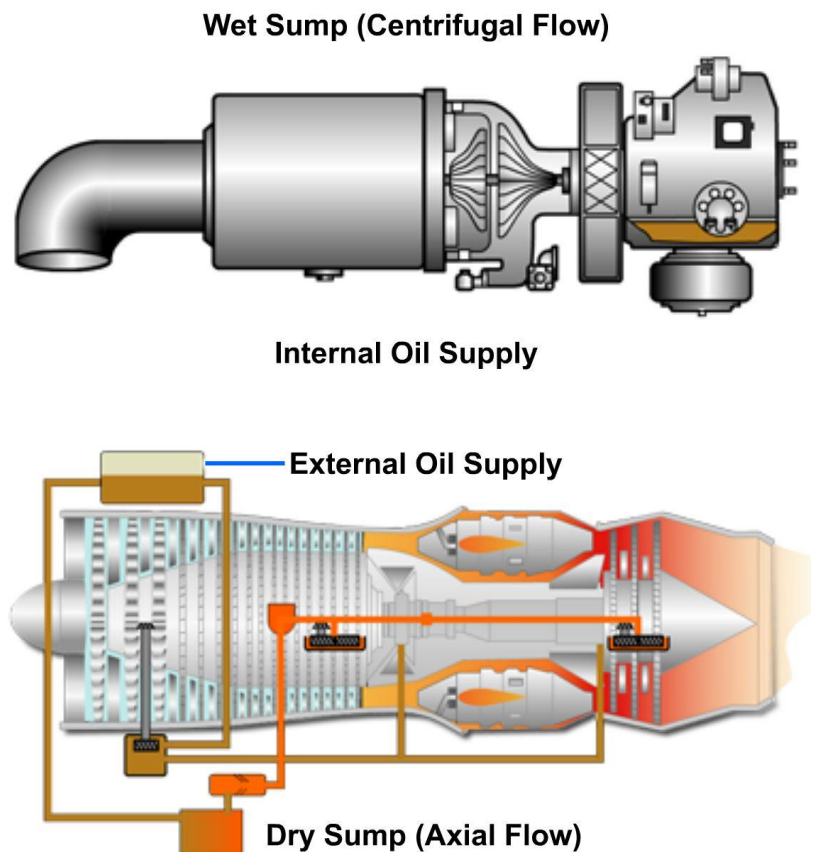


Figure 5-2 — Dry/wet-sump oil system.

Dry-Sump System

The dry-sump system shown in *Figure 5-2* is the most common. In the dry-sump lubrication system, a tank located in the airframe or mounted on the engine holds the oil supply. This type of system carries a larger oil capacity, and an oil cooler is usually included to control temperature. The lubrication design of the engine may use either an air-oil or a fuel-oil cooler. The axial-flow engines keep their comparatively small diameter through a streamlined design of the oil tank and oil cooler.

Oil System Components

As we just discussed, there are two primary types of oil systems. Some of these parts are unique to one type of system, while other parts are used in both systems. The following paragraphs cover oil system parts regardless of type unless otherwise noted. The main parts of a typical oil system include an oil tank, oil pumps, valves, filters, and chip detectors. Other parts are oil coolers, oil jets, gauge connectors, vents, and oil system seals.

Oil Tanks

The oil tank stores the system oil supply. An oil tank may be a simple sealed container (similar to a car's fuel tank) where oil is gravity-fed to the engine. Older low-performance aircraft engines could use this simple tank design. Today's high performance aircraft require a more complicated pressurized type of oil tank; this assures positive lubrication during all flight conditions.

The dry-sump oil system uses an oil tank located either in the airframe or mounted on the engine (*Figure 5-3*). Oil tanks mounted on the airframe are normally located within or near the engine compartment. Additionally, designers place it high to gain as much advantage as possible from gravity flow to the oil pump inlet.

A view of a representative oil tank is shown in *Figure 5-4*. It shows a welded aluminum tank

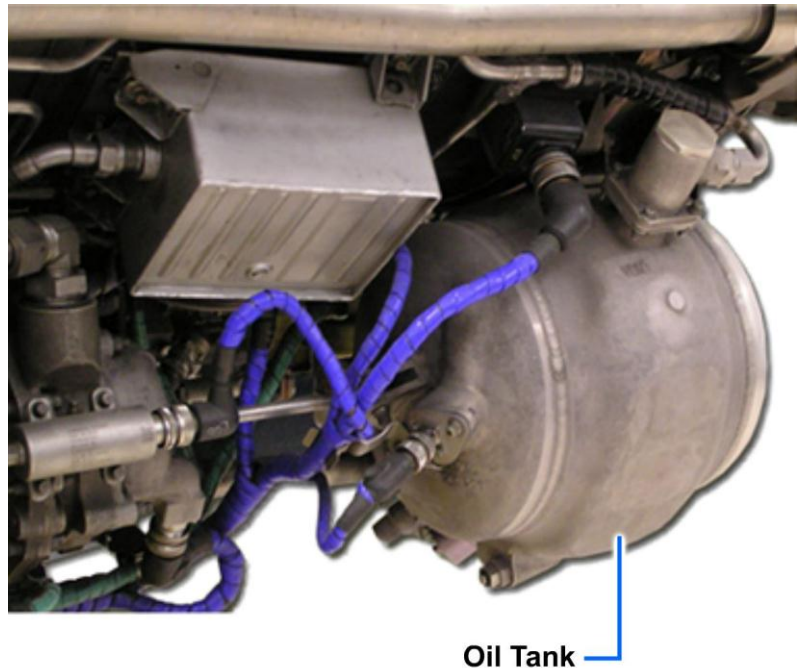
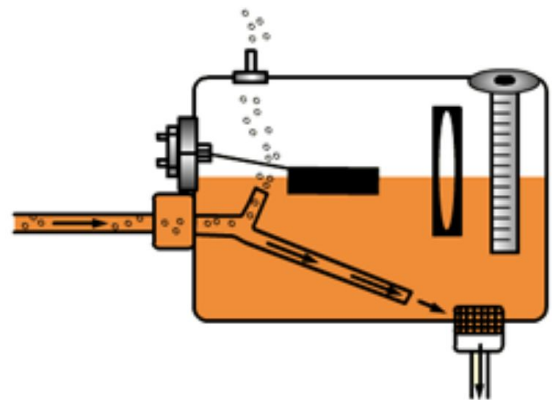


Figure 5-3 — Dry-sump oil tank, engine mounted.



Interaction Available

Figure 5-4 — Representative oil tank.

with an oil capacity of 3.25 gallons and a 0.50-gallon foaming space. The tank is designed to furnish a constant supply of oil to the engine in any attitude, and during negative g loading or forces. This is done by a swivel outlet assembly mounted inside the tank, a horizontal baffle mounted in the center of the tank, two flapper check valves mounted on the baffle, and a positive vent system.

The swivel outlet fitting is controlled by a weighted end, which is free to swing below the baffle. The flapper valves in the baffle are normally open. They close only when the oil in the bottom of the tank rushes to the top of the tank. This happens during decelerations and inverted flight. Oil trapped in the bottom of the tank is picked up by the swivel fitting without any interruption in the flow of oil.

All oil tanks provide an expansion space. This allows for oil expansion from heat and oil foaming. Some tanks also have a deaerator tray for separating air from the oil. Usually these deaerators are of the can type, with oil entering at a tangent. The air released is carried out through the vent system in the top of the tank. The vent system inside the tank is so arranged that the airspace is always vented, even when the aircraft is decelerating and oil is forced to the top of the tank. However, most oil tanks have a pressurized oil tank to assure a positive flow of oil to the oil pump inlet. The tank is pressurized by running the vent line through an adjustable check relief valve.

Another feature common in oil tanks is a sump with drain and shutoff valves in the bottom of the tank. The drain valve permits oil to be drained for oil changes. An oil shutoff valve is a motor operated, gate-type valve attached to the oil sump. This valve can be operated electrically or manually to shut off the oil supply to the engine in emergency conditions.

Some oil tanks include an oil temperature bulb in the outlet line. These bulbs send the temperature of the oil to indicators in the instrument panel. Oil quantity units or sight gauges are also located on the oil tank. A sight gauge gives a visual indication of oil level. A quantity indicator connects electrically to a gauge in the instrument panel. A quantity indicator uses a float-type unit located in the tank and an electrical transmitter on the outside of the tank.

Oil Pumps

The oil pump supplies oil under pressure to engine points that require lubrication. Most lubrication pumps have both a pressure supply element and a scavenge element. However, some oil pumps serve a single function; they either supply or scavenge the oil. The number of pumping elements, both pressure and scavenge, depends largely on the type and model of the engine. For instance, the axial-flow engines have a long rotor shaft and use more bearings than a centrifugal-flow engine. Therefore, there must be more oil pump elements for both supply and scavenging, or they must be of larger capacity.

It is common to use small individual scavenge pumps in the remote sections of an engine. This assures proper scavenging of the lubricating oil. In all types of pumps, the scavenge elements have a greater pumping capacity than the pressure element. This is to prevent oil from collecting in the bearing sumps.

The pumps may be one of several types, each type having certain advantages and limitations. The three most common oil pumps are gear, gerotor, and piston types, the first being the most used and the last the least used. Each of these pump types have several different designs. This makes it impractical to try to completely cover each type. However, a pump representative of each of the three types is discussed.

Gear-Type Oil Pump

The gear-type oil pump has only two elements (one for pressure oil and one for scavenge). However, this type of pump could have several elements.

Notice in *Figure 5-5* a relief valve in the discharge side of the pump. This valve limits the output pressure of the pump by bypassing oil back to the pump inlet. Also notice the location of the shaft shear section, which will allow the shaft to shear if the gears should seize.

Gerotor Oil Pump

The gerotor pump usually has a single element for oil feed and several elements for scavenging oil. Each of the elements, pressure and scavenge, are almost identical in shape.

However, the capacity of the elements is controlled by varying the size of the gerotor elements. The pressure element has a pumping capacity of 3.1 gallons per minute (gpm), compared to a 4.25-gpm capacity for the scavenge elements. So the pressure element must be smaller since the elements are all driven by a common shaft.

Engine revolutions per minute (rpm) determine oil pressure, with a minimum pressure at idling speed and maximum pressure at maximum engine speed. A set of gerotor pumping elements is shown in *Figure 5-6*. Each set of gerotors is separated by a steel plate, making each set an individual pumping unit. Each set consists of an inner element and an outer element. The small star-shaped inner element has external lobes fitting within and matching with the outer element, which has internal lobes. The small element pinned to the pump shaft acts as a drive for the outer free-turning element. In some engine models, the oil pump has four elements, one for oil feed and three for scavenging. Other models have six elements, one for feed and five for scavenge. In each case, the oil flows as long as the engine shaft is turning.

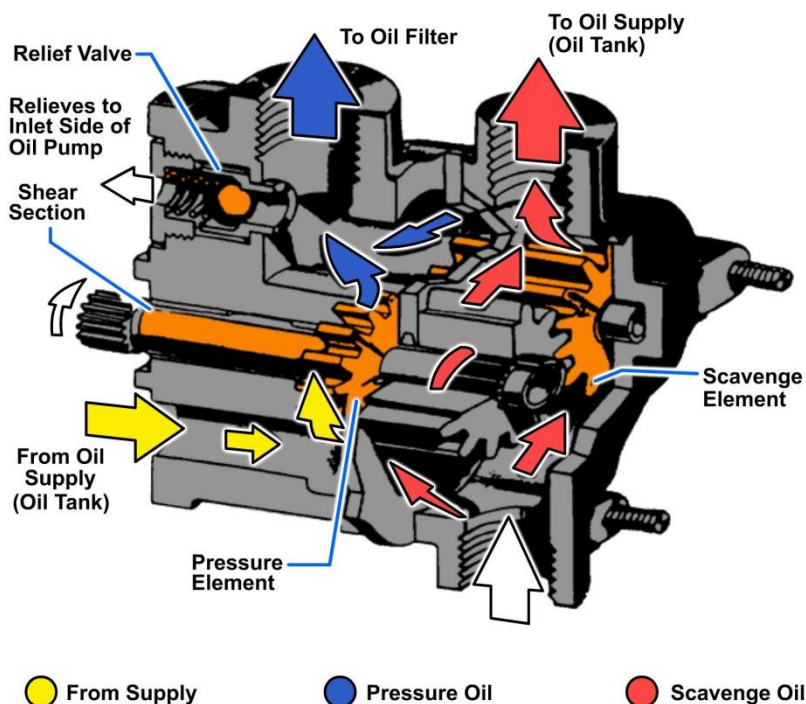


Figure 5-5 — Cutaway view of gear-type oil pump.

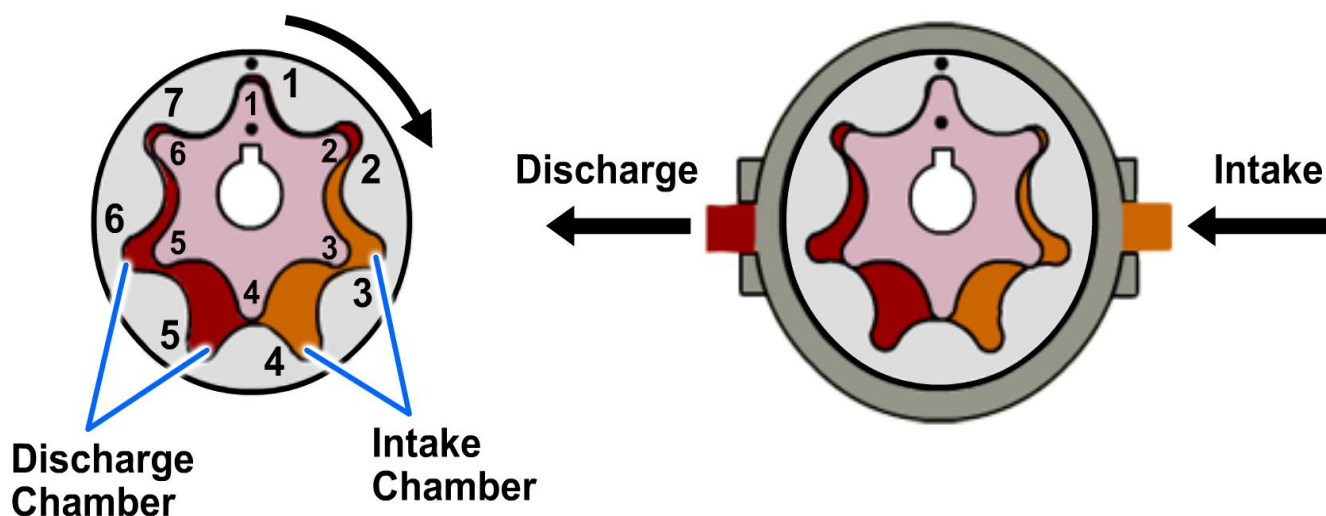


Figure 5-6 — Gerotor pumping element.

Piston Oil Pump

The piston lubrication pump is always a multi-plunger type. Output of each piston supplies a separate jet. Oil drained from the points of lubrication is scavenged by a separate pump element. The piston-type pump shown in *Figure 5-7* is used less than either of the other types.

Valves

Valves control the pressure and flow of oil in the lubrication system. There are three types of valves common to oil systems that are discussed in this text. They are relief valves, check valves, and bypass valves.

Oil Pressure Relief Valve

An oil pressure relief valve limits the maximum pressure within the system. The relief valve is preset to relieve pressure and return the oil to the inlet side of the lube pump. This valve is important if the system has an oil cooler, because the cooler's thin walls rupture easily.

Check Valves

Check valves installed in the oil supply lines or filter housings prevent oil in the reservoir from seeping (by gravity) into the engine after shutdown. Check valves prevent accumulations of undue amounts of oil in the accessory gearbox, rear of the compressor housing, and combustion chamber. Such accumulations could cause excessive loading of accessory drive gears during starts, contamination of the cockpit pressurization air, internal oil fires, and hot starts.

The check valves are usually of the spring-loaded ball-and-socket type, constructed for free flow of pressure oil. The pressure required to open these valves will vary. Most valves require from 2 to 5 pounds per square inch (psi) permitting oil to flow to the bearings.

Thermostatic Bypass Valves

Thermostatic bypass valves are included in oil systems using an oil cooler. Their purpose is to maintain proper oil temperature by varying the proportion of the total oil flow passing through the oil cooler. A cutaway view of a thermostatic bypass valve is shown in *Figure 5-8*. This valve consists of a valve body (having two inlet ports and one outlet port) and a spring-loaded thermostatic element valve.

The valve is spring-loaded so the valve will open (bypassing the cooler) if the pressure through the oil cooler drops too much because of denting or clogging of the cooler tubing.

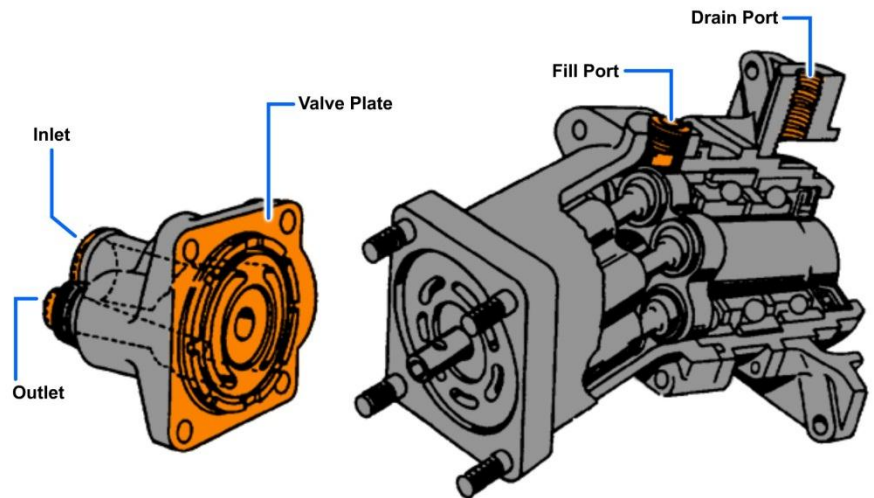


Figure 5-7 — Axial piston pump.

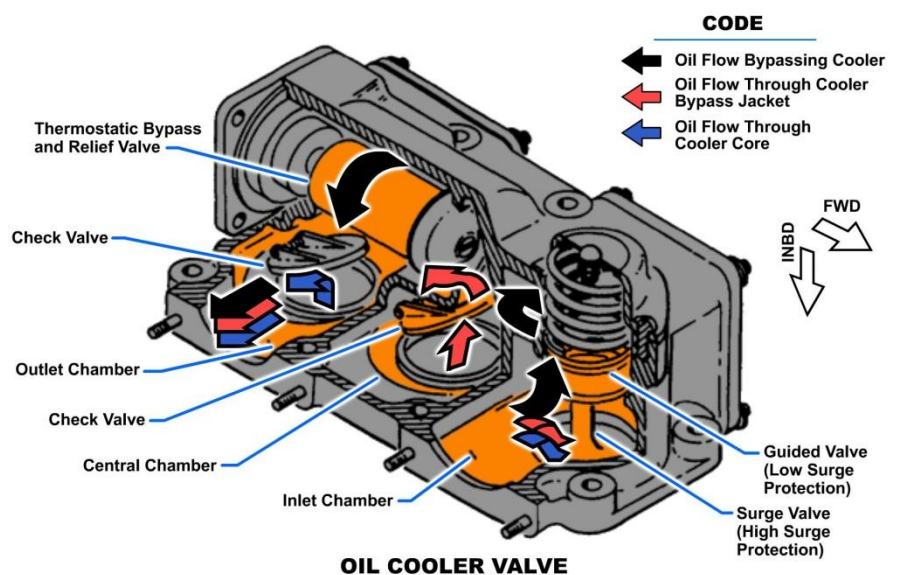


Figure 5-8 — Thermostatic bypass valve.

Filters

The filters are an important part of the lubrication system, since they remove most foreign particles in the oil. Without some type of filter in the oil system, dirt or metal particles suspended in the oil could damage bearings, clog passages, and cause engine failure.

The filter bypass valve allows oil to flow around the filter element if it becomes clogged. The bypass valve opens whenever a certain pressure differential is reached because the filter became clogged. When this occurs, the filtering action is lost, allowing unfiltered oil to be pumped to the bearings. This is a dangerous situation; however, unfiltered oil is better than no oil.

There are several types of filters used for filtering the lubricating oil. The filtering elements come in a variety of configurations. The parts of a main oil filter include a housing that has an internal relief valve and a filtering element.

Disk-Type Filter

The disk filter shown in *Figure 5-9* consists of a series of spacers and screens. The screens and spacers are stacked alternately in the housing. The spacer's direct oil through the screens as it flows through the assembly. The screen mesh (usually measured in microns) determines the size of foreign matter allowed to pass through the filter.

Micronic-Type Filter

The micronic filter is similar to the cartridge filter used on a car's oil filter, as shown in *Figure 5-10*. It uses either a paper or metal cartridge type of oil filter. The paper filtering element is removed and replaced, while the metal type is cleaned and reused.

The filter types just discussed are generally used as main oil filters. These filters strain the oil as it leaves the oil pump. In addition to main oil filters, there are also secondary filters throughout the system. For instance, there may be a finger screen filter to trap large metal pieces before the magnetic drain plug. Also, there are the fine mesh screens (last-chance filters) for straining the oil just before it passes through the spray nozzles onto the bearing surfaces.

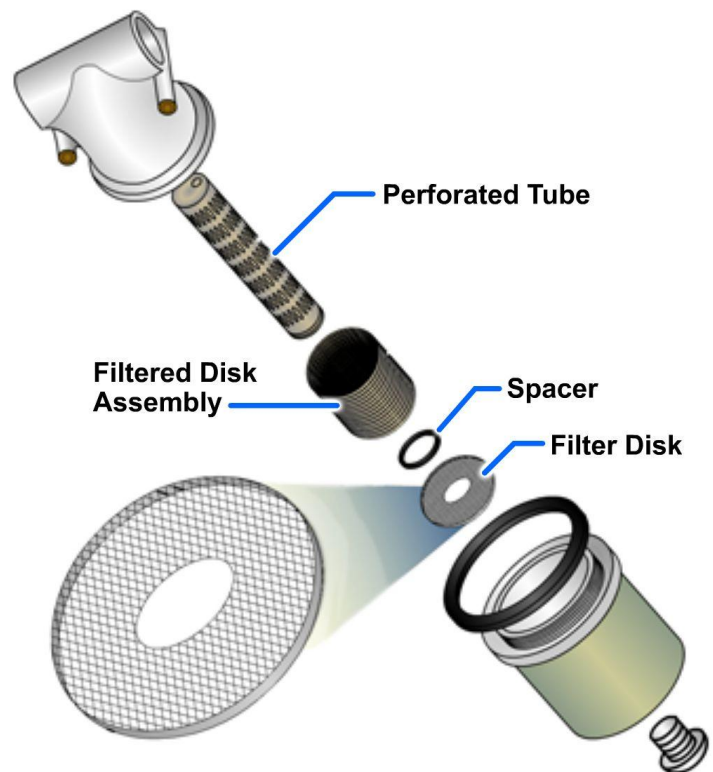


Figure 5-9 — Spacers-and-screens oil filter.

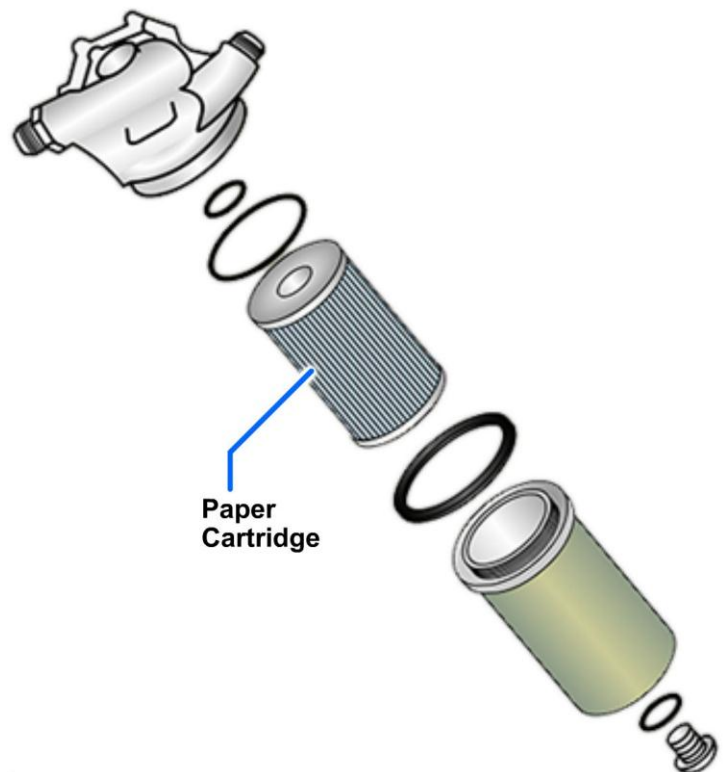


Figure 5-10 — filtering assembly.

Chip Detectors

The magnetic-chip detector is a metal plug with magnetized contacts, and is placed in the scavenged oil path. There are two types—remote-indicating and non-indicating. Both types have magnetized contact points to collect metal particles. When enough metal particles collect on the magnetized contacts, the remote-indicating type completes a circuit between the contacts. This illuminates a warning light in the cockpit, advising the pilot of metal contamination. This indicates that one of the engine gears, bearings, or other metal parts might have failed. The non-indicating chip detector gives no cockpit indication. Instead, it is removed and inspected at regular intervals for metal particles.

Oil Coolers

Oil coolers reduce the temperature of the oil by passing it near streams of air (in the case of the air-oil cooler) or fuel (in the case of the fuel-oil cooler) so it can shed heat. These coolers keep the temperature of the oil within the proper range.

Air-Oil Cooler

The air-oil type cooler is installed at the entry end of the engine as an integral part of the engine (Figure 5-11). This type of cooler is usually an aircraft part conforming to the inlet duct design of the airframe. This cooler is made of rectangular-sectioned aluminum tubing, spirally wound between two end flanges and formed, by welding, into a cylinder.

Two bosses, located on the horizontal center plane, are provided for oil inlet and outlet connections. This type of cooler acts as an inlet air duct; therefore, a cooling effect occurs when the engine is operating. The cooling capacity of each of the oil cooler assemblies depends upon the amount of air allowed to pass through the cooler. Some aircraft use a controllable oil cooler door, which restricts the opening of the oil cooler exit duct to control the air intake.

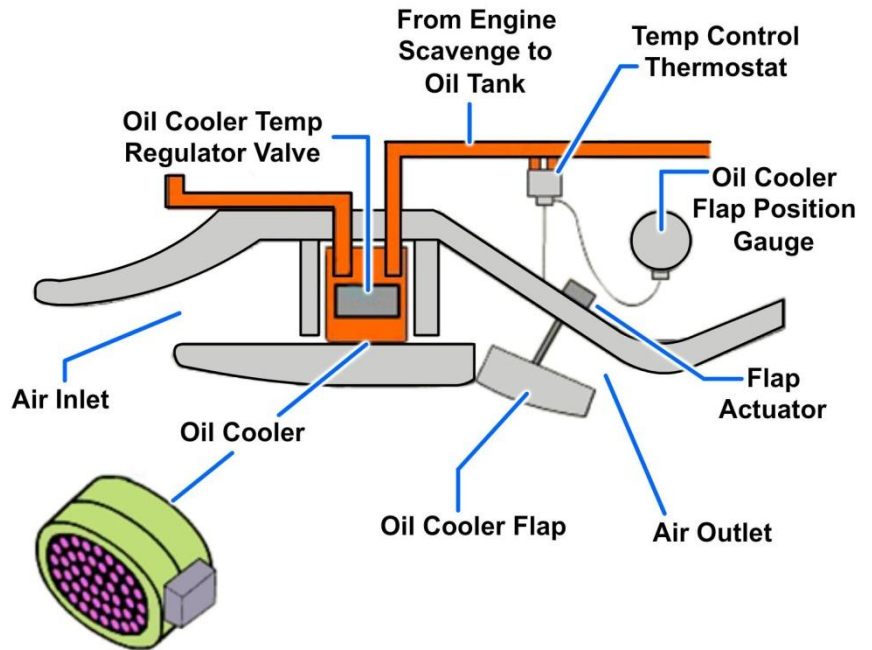


Figure 5-11 — Air-oil type of oil cooler.

Fuel-Oil Coolers

The fuel-oil cooler or heat exchanger shown in Figure 5-12 cools the hot oil and preheats the fuel for combustion. Fuel flow to the engine must pass through the heat exchanger. However, a thermostatic valve controls the oil flow, so the oil may bypass the cooler if no cooling is needed. The fuel-oil heat exchanger consists of a series of joined tubes with an inlet

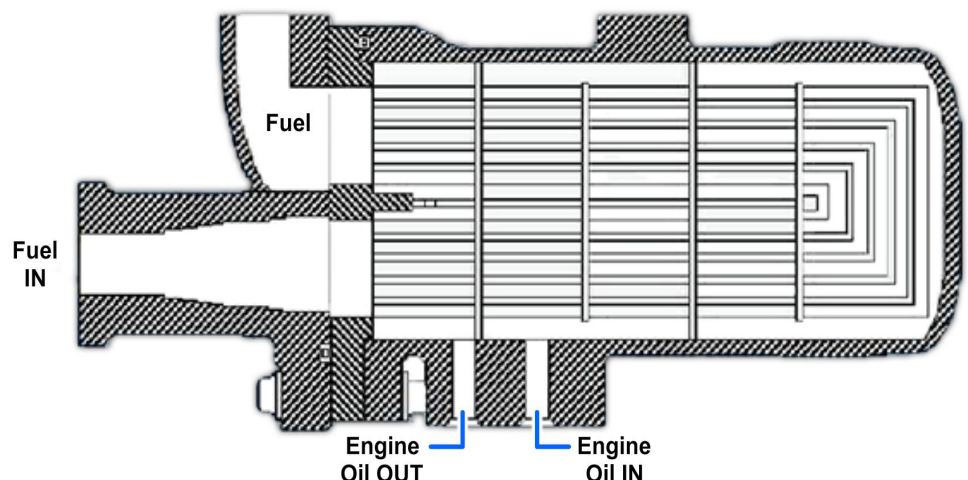


Figure 5-12 — Fuel-oil heat-exchanger type of cooler.

and an outlet port. The oil enters the inlet port, flows around the fuel tubes, and goes out the oil outlet port.

The heat-exchanger type of cooler has the advantage of allowing the engine to keep its small frontal area. Since the cooler is flat and mounted on the bottom side of the engine, it offers little drag. This type of cooler is an engine part.

Oil Jets

The oil jets (or nozzles) are in the pressure lines next to or within the bearing compartments and rotor shaft couplings. The oil from these nozzles is delivered as an atomized spray. Some engines use an air-oil mist type of nozzle spray. This air-oil mist is produced by tapping high-pressure bleed air from the compressor and mixing it with the oil. This method is adequate for ball and roller type of bearings; however, the solid oil spray method is better.

Some engines have “expendable oil” jets to lubricate the bearings supporting the turbine rotor shaft. The air-oil mist from such jets is not returned to the tank, but is discharged overboard.

Gauge Connections

Gauge connections are used in the oil system for oil pressure and oil temperature. The oil pressure gauge is found in all systems to measure the pressure of the lubricant. Because oil pressure is the best indication that the system is operating properly, the oil pressure gauge is vital.

The oil pressure gauge connection is always located in the pressure line between the pump and the various points of lubrication. The oil temperature gauge connection may be located in either the pressure or the scavenge line. However, the scavenge line is preferred, since this location permits a more accurate indication of the actual bearing temperatures, as the temperature of the oil shortly after it leaves the bearings is indicated. The most common types of oil temperature indicators are a thermocouple-type fitting or an oil temperature bulb.

Vents

Vents are lines or openings to the atmosphere in the oil tanks or accessory cases of the engine. The purpose of the vent in an oil tank is to keep the pressure within the tank from rising above or falling below that of the outside atmosphere. However, the vent may be routed through a pressure relief valve that keeps pressure on the oil system to assure positive flow.

In the accessory case, the vent (or breather) is a screen-protected opening that allows accumulated air pressure to escape. The scavenged oil carries air into the accessory case, and this air must be vented. Otherwise, the pressure buildup within the accessory case would stop the flow of oil draining from the No. 1 bearing. This oil would be forced past the rear bearing oil seal and into the compressor housing. Oil leakage could cause any of several problems, including high oil consumption, cockpit air contamination, or a fire. An oil leakage around the combustion area or turbine area could cause burning and engine failure.

The screened breathers are usually located in the front center of the accessory case to prevent oil leakage through the breather. Some breathers have a baffle to prevent oil leakage during flight maneuvers.

A vent that leads directly to the No. 1 bearing compartment may be used in some engines. This vent equalizes pressure around the front bearing surface. Then the lower pressure at the first compressor stage will not force oil past the No. 1 bearing rear carbon oil seal and into the compressor.

Oil System Seals

Any system containing fluids needs some type of seal to prevent fluid loss. **The importance of oil seals cannot be overemphasized!** An improperly installed or leaking seal in the oil system could cause bearing failure, fire, or cockpit fumes. This could result in loss of aircraft or LIFE. There are three types of seals used in jet engine oil systems—synthetic, carbon, and labyrinth.

Synthetic Seals

Seals, packings, and O-rings are used where metal-to-metal contact prevents proper sealing. These seals come in many different shapes and sizes and are not reusable. It is important to use the proper seal (identified by correct part number) for the specific installation. NEVER choose a seal, packing, or O-ring because it looks right. A seal designed to have excellent sealing characteristics in one environment could be hazardous when used in another. For instance, some seals swell when contacted with MIL-PRF-7808 oil, while others deteriorate completely.

Carbon Seals

Carbon seals are used to contain the oil in the bearing areas. Carbon seals form a sealing surface by having a smooth carbon seal rub against a smooth steel surface (faceplate). All carbon seals are preloaded. Preloading means the carbon seal is held against the steel surface. Three common methods of preloading carbon seals are spring tension, centrifugal force, and air pressure.

Labyrinth Seals

Labyrinth seals contain series of knifelike, soft metal edges that ride very close to a steel surface. A certain amount of air, taken from the compressor, is forced between the steel surface and soft metal edges to prevent oil leakage between sections. These seals were used as main bearing seals in earlier engines. These seals are made of very soft metal and used at main bearing areas. Small nicks in the seal can cause major oil leaks and premature engine changes.

ENGINE OIL SYSTEM DESCRIPTION

The engine oil system shown in *Figure 5-13* is a representative engine of a self-contained, pressurized, recirculating, dry-sump system. It consists of the following components:

1. Tank
2. Oil pressure and scavenge pump
3. Oil filter and condition monitoring system
4. Oil coolers
5. Chip detector

Oil Tank

The oil tank and air/oil cooler are integral parts of an aluminum casting. The filler port is on the right side of the engine, and the filler design makes it impossible to over-service the tank. Oil flows to the oil pump through a screen. The oil level is shown by a sight gauge on each side of the tank. The scavenge pump returns oil from the sumps and accessory gearbox to the oil tank through six scavenge screens.

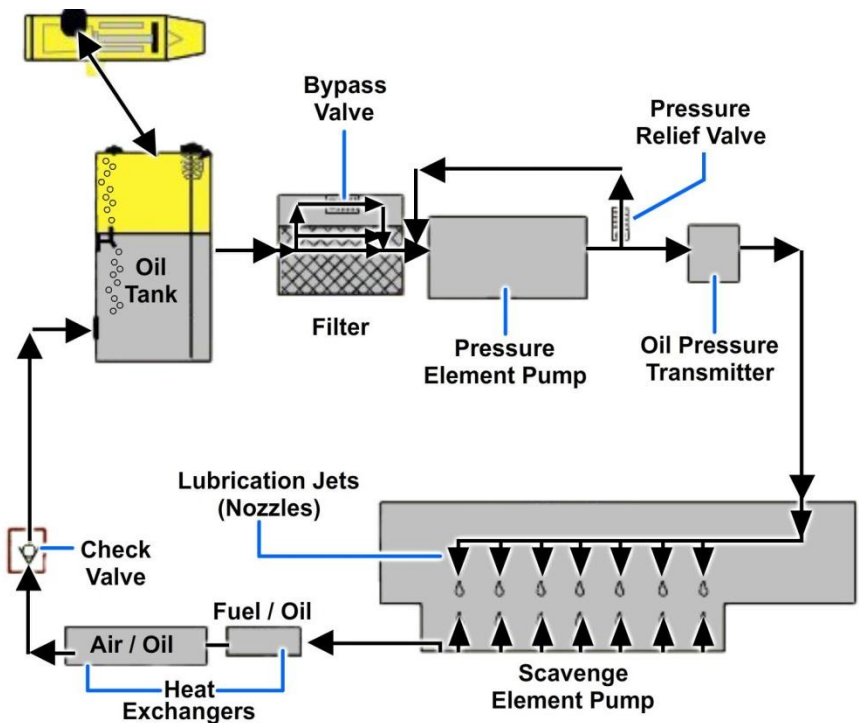


Figure 5-13 — Engine oil system schematic.

Oil Pressure System

Oil suctioned through the pressure element of the pump is pressurized and flows through the oil filter. The oil then flows into passages in the accessory gearbox and to the six main bearings in the sumps. A cold-start relief valve downstream of the filter protects the system by dumping any extra oil into the accessory gearbox case. Air jets blow across the oil jets to provide continuous oil mist lubrication. The engine has two sets of oil jets to provide each main bearing with oil for cooling and lubrication. Scavenge to the scavenge elements of the pump flows through screens at the pump inlet, and then through the electrical chip detector. The oil then flows through the oil cooler, main frame, scroll vanes, and into the oil tank. If the oil pressure drops below 24 psi, the appropriate ENGINE OIL PRESS caution light will illuminate in the cockpit.

Oil Filter

Oil discharged from the oil pump is routed to a disposable element. The element is a 3-micron filter located on the forward, left-hand side of the Accessory Gear Box (AGB). As the pressure differential across the filter increases, the first indication will be a popped impending bypass button. As the pressure increases, the OIL FLTR BYPASS caution light will illuminate at the same time the filter bypass occurs.

Oil Coolers

Scavenge oil is cooled before it returns to the tank by a fuel/oil cooler. After passing through the oil cooler, oil enters the top of the main frame. At this location it flows through the scroll vanes that function as an air/oil cooler. This further cools the oil and heats the vanes for full-time anti-icing. The vanes discharge oil into the oil tank. If the oil cooler pressure becomes too high, a relief valve will open to dump scavenge oil directly into the oil tank.

Engine Chip Detector

The chip detector is on the forward side of the accessory gearbox. It consists of a housing with an integral magnet and electrical connector, with a removable screen surrounding the magnet. If there are chips, the completed circuit illuminates the appropriate engine number's *CHIP DETECTED warning light*.

MAINTENANCE OF THE LUBRICATION SYSTEMS

Maintenance of the oil system is an item of major importance to the (AD). It consists mainly of adjusting, removing, cleaning, and replacing various parts. To troubleshoot and repair oil systems effectively, you should be thoroughly familiar with both the external and internal oil systems.

Location of Leaks and Defects

The immediate location of any leak or defect within the oil system of any aircraft engine is important. The life of the engine is dictated by its oil supply. Whenever a leak develops or the oil flow is restricted, a part failure or loss of the engine may result.

Locating leaks in the external oil system is easy. Often a visual inspection shows a loose line or leaking gasket. However, you should never assume that an obvious corrective action is all that is needed.

Replacement of Gaskets, Seals, and Packing's

A large portion of the maintenance involved is the replacement of parts and repair of various oil leaks. Much of this maintenance requires the use of new gaskets, seals, and packings.

New seals are packaged to prevent damage. These packages are identified from technical information printed on the package. This information (shown in *Figure 5-14*) identifies the use and qualifications of the packing. Besides the part number, the manufacturer's cure date is one of the most important items listed on the package. Refer to Department of Defense (DOD) 4140.27 for shelf life of preformed packings. Most synthetic rubbers are not damaged by several years of storage under ideal conditions. However, they deteriorate quickly when exposed to heat, light, moisture, and various other conditions. This is why it is important to keep them in their original envelopes. Damage also occurs to packings when improperly stored, such as flattening or creasing from storage under heavy parts. Before using the parts, inspect new seals for damage (nicks, scratches, flattening, over-age). Do not use over-aged, damaged or non-identifiable seals (seals removed from original envelopes). The difficulty encountered whenever a gasket, seal, or packing is being replaced is in proper installation. Always check that the mating surfaces are clean, and that the new gasket, seal, or packing is correctly installed. Seals or O-rings are comparatively soft, so you should use care to prevent nicks and scratches; do not use sharp instruments during installation. Always refer to the applicable MIM for the correct procedures, tools, and lubricants used during installation.

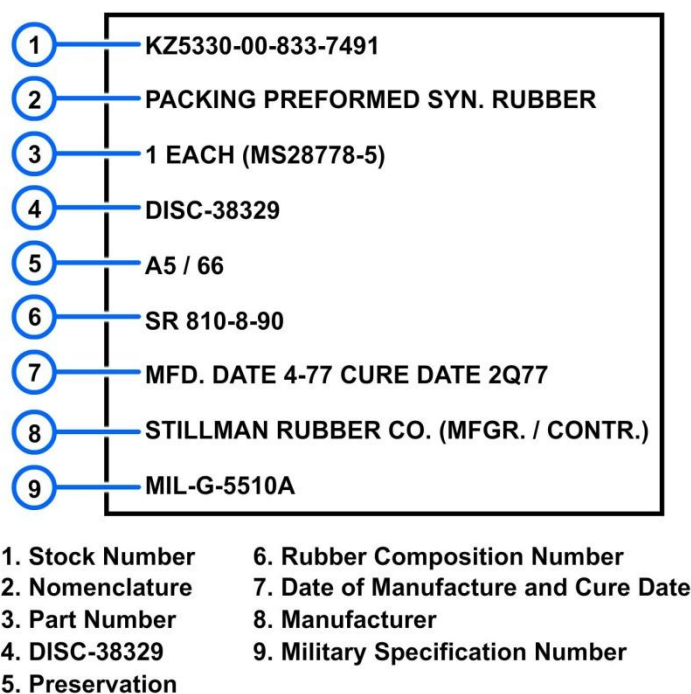


Figure 5-14 — Seal packing information.

 **WARNING** 

Always refer to the applicable MIM's prior to any maintenance actions performed

Adjustment of Oil Pressures

Before making any oil pressure adjustments, you should first check the oil pressure with a direct reading gauge. Record the oil pressure when running the engine at the recommended oil temperature and engine rpm. Oil pressure adjustments are made with the adjusting screw on the oil pressure relief valve of the oil pump. Turn the adjusting screw clockwise to increase and counter clockwise to decrease.

 **WARNING** 

Some engines prohibit decreasing oil pressure; the oil pump must be changed instead. High oil pressure could indicate blocked oil passages and lowering the oil pressure could result in an inadequate oil supply to some bearings.

After any adjustments, you must recheck the pressure with a direct reading gauge at the recommended oil temperature and engine rpm.

To identify defects in the oil systems that are attributable to either high or low oil pressure, refer to *Table 5-3*.

Table 5-3 — Low/High Oil Pressure Defects

<i>Trouble</i>	<i>Probable Cause</i>	<i>Corrective Action</i>
High oil pressure. Indicator accuracy must be confirmed using direct reading oil pressure gauge.	Low oil temperature. Improper setting of relief valve. Defective pressure indicator.	Check temperature indicator. Check grade of oil. Reset pressure relief valve. Replace with new or serviceable indicator.
Low oil pressure. Indicator accuracy must be confirmed using direct reading oil pressure gauge.	High oil temperature. Clogged oil filter. Improper setting of relief valve. Defective pressure pump. Defective pressure indicator. Low oil level. Viscosity of oil is too light. Air leak in the supply line.	Check temperature indicator. Remove and clean oil filter. Reset pressure relief valve. Repair or replace pump. Replace with new or serviceable indicator. Fill oil tank to the proper level. Drain system; refill with correct grade of oil. Locate and eliminate air leak.
Reduction gear oil pressure out of limits. The reduction gear has a fixed orifice oil system. The problems described are often caused by a change in the effective orifice or the pump output. Reduction gear and pump pressure may only be adjusted to increase pressure. Indicator accuracy must be confirmed using direct reading oil pressure gauge.	Reduction gear oil pump assembly pressure element deteriorated (low pressure), check valve stuck or restricted (low pressure). Reduction gear oil pump drive train bearing or gear failure (low pressure). Reduction gear internal oil passages blocked (high pressure) or ruptured (low pressure), worn transfer tubes (low pressure). Oil system air lock. Reduction gear pressure relief valve stuck open (low pressure).	Repair/replace as required. Replace engine. Prime reduction gear pump assembly. Clean/replace as required.

NOTE

The screen and spacer-type filters require a special holding fixture for replacing (buildup) the filter elements. Be sure the screen and spacers are the correct number and in proper order.

Removal and Replacement of Oil Filters

The following procedures are general procedures. You should refer to the correct MIM before you remove or replace oil filters on your engine. Oil filters are removed and inspected at regular intervals. They are also inspected when the cockpit indicator (chip light) for the magnetic drain plug warns of possible failure (*Figure 5-15*).

1. Provide a suitable container for collecting oil and remove the filter.
2. Inspect the filter for metal contamination.
3. After inspection, clean the filters. Most filters are routed to the Fleet Readiness Center (FRC) /Aircraft Intermediate Maintenance Department (AIMD) for ultrasonic cleaning.
4. Install clean or new filters on the oil filter assembly.
5. Install the filter assembly using new O-rings and gaskets. Torque nuts to recommended values.

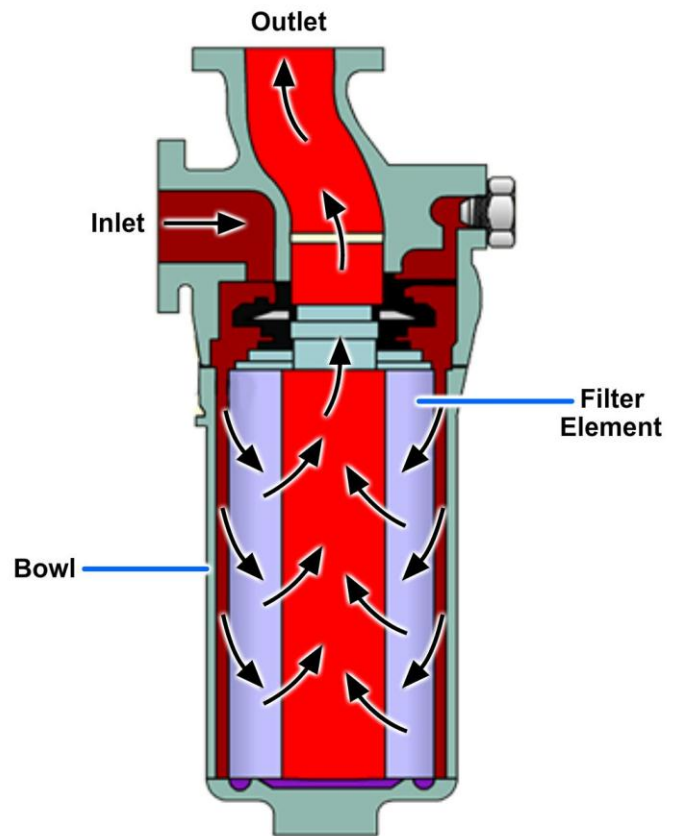


Figure 5-15 — Oil filter assembly.



Figure 5-16 — Types of magnetic drain plugs with contamination.

Removal and Replacement of Magnetic Drain Plugs

Magnetic drain plugs are usually removed and inspected at the same time as the main oil filters. Remove magnetic drain plugs carefully so contaminants will not be disturbed until inspected. *Figure 5-16* shows types of magnetic drain plugs.

Metal Particle Identification

Metal particles found on the oil strainer screens and magnetic plugs indicate a possible failed part or impending engine failure. The presence of metal particles on the oil screen or on the magnetic plug does not mean that the engine must be replaced. The type (steel, bronze), shape (flakes, chunks), and quantity determine the source and dictate whether or not an engine is serviceable. The metals usually found are steel, tin, aluminum, silver, copper (bronze), chromium, nickel, and

tin cadmium combinations. With some experience you can make a visual inspection of the color and hardness, and it will help you to identify the metal particles. The particles of metal found in an engine may be granular, flake, or chunk shape.

When a visual inspection does not positively identify the metal, the kind of metal may be determined by a few simple tests. These tests are performed with a permanent magnet and an electric soldering iron. You also need about 2 ounces each of concentrated hydrochloric (muriatic) acid, concentrated nitric acid, chromic acid, and sodium or potassium hydroxide.

NOTE

Fuzz consists of fine, hair-like particles resulting from normal wear. Fuzz accumulation may be more noticeable on new engines during the first 100 hours of operation. Always refer to your specific aircraft and engine MIM for contamination and serviceability limits. Rejection criteria for one engine type may be only an oil flush and oil component replacement on another engine type.

The following test procedures help determine different types of metal particles:

- Iron (Fe) and nickel (Ni). Use a permanent magnet to isolate these metal particles.
- Tin (Sn). Tin particles can be distinguished by their low melting point. Use a clean soldering iron, heated to 500 °F (250 °C) and tinned with a 50-50 solder (50-percent tin and 50-percent lead). A tin particle dropped on the soldering iron will melt and fuse with the solder.
- Aluminum (Al). Aluminum particles can be determined by their reaction with hydrochloric acid. When a particle of aluminum is dropped into the hydrochloric (muriatic) acid, it will fizz, and the particle will gradually disintegrate. Aluminum particles will also dissolve rapidly and form a white cloud in a strong caustic solution (sodium or potassium hydroxide). Silver and copper (bronze) do not noticeably react with hydrochloric acid.
- Silver (Ag) and copper (Cu). Silver and copper (or bronze because of its high copper content) may be differentiated by their respective reactions in nitric acid. When a silver particle is dropped into nitric acid, it will react with the acid, slowly producing a whitish fog. When a particle of copper (bronze) is dropped into the nitric acid, it will react rapidly with the acid. This reaction produces a bright, bluish-green cloud.
- Chromium (Cr). These particles may be determined by their reaction to hydrochloric acid. When a chromium particle is dropped into concentrated hydrochloric acid, the acid will develop a greenish cloud.
- Cadmium (Cd). Cadmium particles will dissolve rapidly when dropped into a 5-percent solution of chromic acid.
- Tin cadmium. These particles will dissolve rapidly when dropped into a 5-percent solution of chromic acid. The tin content will cause a clouding of the solution.



Always use the appropriate protective clothing and equipment, and use extreme care when handling acids.

Make sure the metal particles found in the oil are of an acceptable quantity for the engine to remain in service. Always refer to the applicable MIM for the limits of metal particles for each particular engine.

JOINT OIL ANALYSIS PROGRAM (JOAP)

The Joint Oil Analysis Program (JOAP) provides a diagnostic technique to monitor and diagnose equipment or oil condition. This is done without the removal or extensive disassembly of the equipment. It is mandatory for all activities operating aeronautical equipment to participate in this program. Type commanders or the Cognizant Field Activity (CFA) are the only ones to relieve you from this requirement. The CFA provides information on the sampling points, techniques, and intervals for all Navy equipment. The CFA also establishes and maintains sampling information for the Maintenance Requirements Cards (MRCs) and maintains updated MIMs with the contamination and serviceability limits of the respective equipment or weapon systems.

Spectrometric Oil Analysis

A diagnostic maintenance tool used to determine the type and amount of wear metals in lubricating fluid samples. Engines, gearboxes, and hydraulic systems are the types of equipment most frequently monitored. The presence of unusual concentrations of an element in the fluid sample indicates some abnormal wear of the equipment. Once the abnormal wear is verified and pinpointed, the equipment may be repaired or removed from service. This is done before a major failure of the fluid-covered part occurs. This philosophy enhances personnel safety and material readiness at a minimum cost, and serves as a decisive tool in preventive maintenance action. Thus, worn parts may be replaced prior to a catastrophic failure.

Wear Metals

Wear metals are generated by the motion between metallic parts, even though lubricated. For normally operating equipment, the wear metal is produced at a constant rate. This rate is similar for all normally operating equipment of the same model. Any condition that changes the normal relationship will accelerate the rate of wear and increase the quantity of wear metal particles produced. If the condition is not corrected, the deterioration will increase and cause secondary damage to other parts of the assembly. This can result in the final failure of the entire assembly and loss of the equipment. New or newly overhauled assemblies tend to produce wear metal in high concentrations during the initial break-in period.

Identification of Wear Metals

The wear metals produced in fluid-lubricated mechanical assemblies can be separately measured. This is done in extremely low concentrations, by spectrometric analysis of fluid samples taken from the assembly. Two methods of spectrometric oil analysis are currently used to measure the quantity of various metals.

1. Atomic Emission—The emission spectrometer is an optical instrument used to determine the concentration of wear metals in the lubricating fluid. This analysis is accomplished by subjecting the sample of fluid to a high-voltage spark. This energizes the atomic structure of the metal elements and causes the emission of light. The emitted light is focused into the optical path of the spectrometer and separated by wavelength. It is then converted to electrical energy, and measured. The emitted light for any element is proportional to the concentration of wear metal suspended in the lubricating fluid.
2. Atomic Absorption—The atomic absorption spectrometer is an optical instrument. It is also used in determining the concentration of wear metals in the lubricating fluid. The fluid sample is drawn into a flame and vaporized. The atomic structure of the elements present becomes sufficiently energized by the high temperature of the flame to absorb light energy. Light energy having the same characteristic wavelength as the element being analyzed is radiated through the flame. The resultant light is converted to electrical energy and measured electronically. The

amount of light energy absorbed by the elements in the flame is proportional to the concentration of wear metals.

NOTE

The spectrometric fluid analysis method is effective only for those failures that are characterized by an abnormal increase in the wear metal content of the lubricating fluid. This is particularly true of failures that proceed at a rate slow enough to permit corrective action. This is done after receipt of notice from the laboratory.

The value of a spectrometric analysis is based on the assumption that the oil sample is representative of the system from which it is taken. Occasionally, samples from one part may be substituted for another, resulting in a false appearance of a developing wear condition. A sudden increase of wear metal in one part and a decrease in another should be considered as a problem related to sample error; for example, misidentifying a sample as an engine sample when it was actually a transmission sample.

Oil Sampling Techniques

Sampling intervals should be as close as possible to specified times without interfering with scheduled operations. Generally, the sampling intervals should not vary more than ± 10 percent from specification. This requirement must be considered when equipment is scheduled for detachments or missions away from the home base. Oil samples will still be due while away. The customer (the squadron or detachment) is responsible for coordinating oil analysis support at mission or transit site(s).

NOTE

Refer to the applicable scheduled maintenance or periodic inspection document for the specific routine sampling interval. Also look for specific sampling instructions for each type/model/series of equipment being sampled.

Each operating activity participating in the JOAP must take routine samples properly and at the prescribed intervals. In addition to the routine samples, each operating activity is required to submit special samples under the following conditions:

- When samples are requested by the CFA or by the laboratory.
- When the activity is so directed by the unit maintenance officer to check out suspected deficiencies.
- When abnormal conditions exist, such as malfunction of the oil lubricated part, damage to the oil lubricating system, excessive engine oil loss, or zero oil pressure.
- Before and after the replacement of major oil lubricating system parts.
- At the completions of a test cell run. If the repaired or suspect unit is operated on oil previously used in the test cell system, a sample must be taken. This is done before and after the completion of the test cell run.

- After the final test on an aircraft that is undergoing rework or scheduled depot-level maintenance or after installations of new/overhauled engines or engines repaired by FRC/AIMD.
- Following all accidents, regardless of cause and resulting damage. These samples must be taken by any means possible to get a representative sample.

There are two basic methods of taking a fluid sample: (1) the dip tube technique, and (2) the drain technique.

Dip Tube Sampling

The following procedures should be followed when using the dip tube method for getting a fluid sample:

1. Remove the filler cap from the oil tank and open the sample bottle.
2. Use a sampling tube of the correct length. Hold the tube at one end and lower it into the tank through the filler neck until only the upper end protrudes (*Figure 5-17, views A and B*).
3. Allow the lower end of the tube to fill with oil, and then close the upper end with your thumb or finger. Withdraw the tube and drain the trapped oil into the sample bottle. (*Figure 5-17, views C and D*). Repeat this operation until the bottle has been filled to about one-half inch from the top.

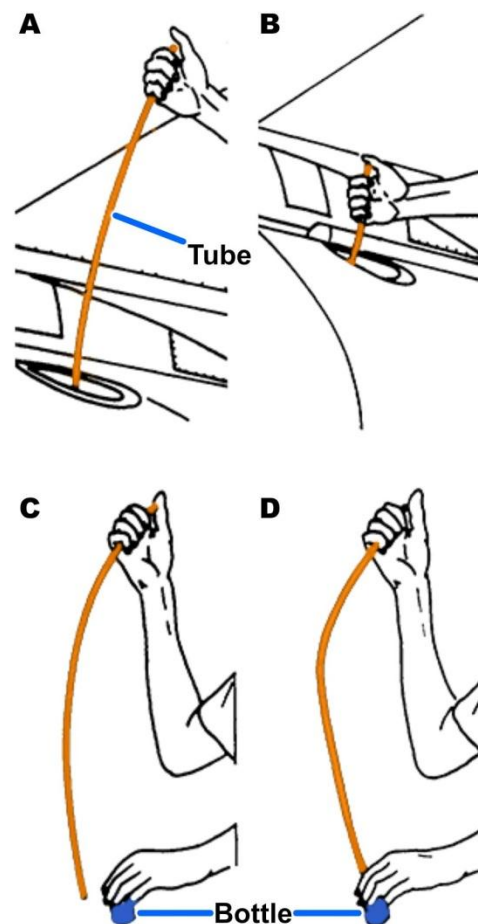


Figure 5-17 — Dip tube oil sampling.



WARNING

Do not use mouth suction to fill the sampling tube. Many oils and fluids are highly toxic and may cause paralysis or death.

4. Replace the bottle cap and tighten it to prevent leakage of the sample. Replace the cap on the tank and discard the sampling tube.
5. Reduce the chance of misidentifying samples by marking all oil samples with equipment/system identification as soon as possible after sampling.

Drain Sampling

When using the drain sampling method for getting a fluid sample, you should use the following procedures:

1. Open the sample bottle.
2. Open the drain outlet in the bottom of the tank, sump, case, or drain port, and allow enough oil to flow through to wash out accumulated sediment (*Figure 5-18, view A*).
3. Hold the sample bottle under the drain and fill to about one-half inch from the top (*Figure 5-18, views B and C*). Close the drain outlet.
4. Replace the bottle cap and tighten it enough to prevent leakage.

Naval Operations Instruction (OPNAVINST) 4731.1 series. The Joint Oil Analysis Program Laboratory Manual, Naval Air Systems Command (NAVAIR) 17-15-50 series, provides instructions for oil sampling and filling out the sample request form DD Form 2026

Table 5-4 — JOAP Lab Recommendation

STANDARD LAB RECOMMENDATION CODES- AERONAUTICAL FOR SPECTROMETRIC ANALYSIS	
CODE	GENERAL LAB RECOMMENDATIONS
A	Sample results normal; continue routine sampling.
Z	Previous recommendation still applies.
	<i>INSPECTION RECOMMENDATIONS (Requires Feedback)</i>
H**	Inspect unit and advise lab of finding. Abnormal wear indicated by *** PPM (element).
R**	Do not fly or operate; inspect filters, screens, chip detector and sumps; advise laboratory of results.
T**	Do not fly or operate. Examine for discrepancy and advise laboratory of results and disposition. If discrepancy found and corrected, continue operation and submit resample after *** hours of operation. If discrepancy is not found, recommend remove component from service and send to maintenance.
	<i>OIL CHANGE RECOMMENDATIONS (Requires Resample)</i>
J*	Contamination confirmed. Change oil; sample after *** minute run-up and after *** operating hours.
W*	Contamination suspected. Change oil; run for *** additional hours, take samples hourly. (This code for Air Force Depot use only.)
	<i>LAB REQUESTED RESAMPLES (Requires Resample)</i>
B*	Resample as soon as possible; do not change oil.
C*	Resample after * * * hours; do not change oil.
E*	Do not change oil. Restrict operations to local flights or reduced load operation, maintain close surveillance and submit check samples after each flight or *** operating hours until further notice.
F*	Do not change oil. Submit resample after ground or test run. Do not operate until after receipt of laboratory result of advice.
G*	Contamination suspected; resample unit and submit sample from new oil servicing this unit.
P*	Do not fly or operate; do not change oil; submit resample as soon as possible.
*Resample (red cap) required **Maintenance feedback required; advise laboratory of findings ***Laboratory will specify time limit	

End of Chapter 5

Jet Aircraft Engine Lubrication Systems

Review Questions

- 5-1. Which property best describes lubrication purposes?
- A. Cooling
 - B. Heating
 - C. Plasma
 - D. Sealing
- 5-2. What are the classifications of lubricants?
- A. Animal, vegetable, petroleum, mineral, liquid
 - B. Animal, vegetable, petroleum, mineral, caustic
 - C. Animal, vegetable, petroleum, mineral, solid
 - D. Animal, vegetable, petroleum, mineral, synthetic
- 5-3. What type of lubricants do jet engines use today?
- A. Animal
 - B. Mineral
 - C. Synthetic
 - D. Vegetable
- 5-4. How many functions must jet engine oils perform?
- A. One
 - B. Three
 - C. Six
 - D. Eight
- 5-5. Which one of the functions must jet engine oils perform?
- A. Cleaning
 - B. Displacing
 - C. Heating
 - D. Melting
- 5-6. What is the military designation for five centistoke turbine engine and gearbox oil?
- A. MIL-L-23699
 - B. MIL-L-7808
 - C. MIL-PRF-23699
 - D. MIL-PRF-87282

- 5-7. Which of the following is considered a grease requirement?
- A. Air resistant
 - B. Cooling resistant
 - C. Fuel resistant
 - D. Water resistant
- 5-8. What are the two types of jet engine lubrication systems?
- A. Dry-sump, cold-sump
 - B. Dry-sump, wet-sump
 - C. Wet-sump, cold-sump
 - D. Wet-sump, hot-sump
- 5-9. Which three jet engine oil pumps are the most common?
- A. Gear, gerotor, piston
 - B. Gear, gerotor, quasi
 - C. Gear, gerotor, redlines
 - D. Gear, gerotor, seimens
- 5-10. What are the three types of seals used in jet engine oil systems?
- A. Carbon, labyrinth, cotton
 - B. Carbon, labyrinth, denim
 - C. Carbon, labyrinth, synthetic
 - D. Carbon, labyrinth, tensile
- 5-11. What is the purpose of a synthetic seal in jet turbine engines?
- A. Used where metal exposure to air prevents proper sealing
 - B. Used where metal-to-metal contact prevents proper sealing
 - C. Used where metal-to-plastic contact prevents proper sealing
 - D. Used where metal-to-carbon contact prevents proper sealing
- 5-12. Where would you find the contamination and serviceability limits of jet engine oil?
- A. Aircraft maintenance instruction manual
 - B. Aircraft illustrated parts breakdown manual
 - C. Aircraft joint oil analysis manual
 - D. Aircraft lubrications manual
- 5-13. What does JOAP provide?
- A. A definition of oil used in jet engines
 - B. A hazmat oil storage reference
 - C. A school for the different types of oils used in jet engines
 - D. A diagnostic technique to monitor and diagnose equipment or oil condition

5-14. What is spectrometric oil analysis?

- A. A diagnostic maintenance tool used to determine engine performance
- B. A diagnostic maintenance tool used to determine aircraft speed
- C. A diagnostic maintenance tool used to determine the type and amount of wear metals in lubricating fluid samples
- D. A diagnostic maintenance tool used to determine fuel burn rate

5-15. Which two basic methods for taking oil samples on jet engines are used on a regular basis?

- A. The dip tube technique and the drain technique
- B. The dip stick technique and the dump technique
- C. The dip probe technique and the drain technique
- D. The dip tube technique and the dump technique

5-16. What is the Department of Defense oil sample request form number?

- A. DD 2026
- B. DD 2501
- C. DD 2525
- D. DD 2569

5-17. What is the general lab inspection recommendation code "R" condition?

- A. Sample results normal; continue routine sampling.
- B. Inspect unit and advise lab of finding. Abnormal wear indicated by metal wear.
- C. Do not fly or operate. Examine for discrepancy and advise laboratory of results and disposition.
- D. Do not fly or operate; inspect filters, screens, chip detector and sumps; advise laboratory of results.

RATE TRAINING MANUAL – User Update

CNATT makes every effort to keep their manuals up-to-date and free of technical errors. We appreciate your help in this process. If you have an idea for improving this manual, or if you find an error, a typographical mistake, or an inaccuracy in CNATT manuals, please write or email us, using this form or a photocopy. Be sure to include the exact chapter number, topic, detailed description, and correction, if applicable. Your input will be brought to the attention of the Technical Review Committee. Thank you for your assistance.

Write: CNATT Rate Training Manager

230 Chevalier Field Avenue

Pensacola, FL 32508

COMM: (850) 452-9700 Ext. 3102 for the N7 Director.

DSN: 922-9700 Ext. 3102 for the N7 Director.

E-mail: Refer to any of the Aviation Rating pages under CNATT on the NKO web page for current contact information.

Rate_____ Course Name_____

Revision Date_____ Chapter Number_____ Page Number(s)_____

Description

(Optional) Correction

(Optional) Your Name and Address
