

CHAPTER 6

PISTON ENGINE COOLING SYSTEMS

Objectives

1. This Chapter has been written with the aim of helping you to satisfy the objectives in the relevant Skills and Knowledge Specification (SAKS) for the trade in the subject area. When you have studied this Chapter, you will be able to:
 - a. State the purpose of a cooling system, whether it be air cooling or liquid cooling.
 - b. State the effects of anti-freeze solutions on the boiling and freezing points of water.
 - c. Describe the components in an air or liquid cooling system, their purpose and the servicing required.
 - d. Describe the methods of heat dissipation in cooling systems.
 - e. State the precautions necessary when handling coolant and the test procedure for the coolant mixture. (See also AP3279A, Section 4, Chapter 8 regarding replenishment and safety precautions.)
 - f. State the effects on an engine of overheating or overcooling.
 - g. State the reasons for agitating water during the testing of a thermostat.

Introduction

2. Apart from the lubrication system, which assists in dissipating heat in an aero-engine, there are two main forms of cooling, namely air cooling and liquid cooling. In this Chapter, we shall discuss the merits of each and describe the two separate systems and their components.
3. The cooling system should so reduce the temperature of an engine that there will be no danger of damage to any of the components. Running an engine too hot will reduce the strength of the oil film at bearings and cylinder walls, and give high local temperature at these points, resulting in possible engine seizure. Running an engine too cool will cause bad fuel/air mixture distribution and a high specific fuel consumption. Therefore, thermal efficiency can only be maintained if the engine is made to run at the highest temperature consistent with the safe working of the metals and oil.

AIR-COOLED ENGINES

Air Cooling

4. The main factors governing the efficiency of an air-cooled engine are:
 - a. Air temperature and speed of air flow.
 - b. The metals used in engine construction.
 - c. Pitch and area of cylinder fins.
 - d. The fitting and design of baffles, cowlings and gills.

General

5. Cooling of an air-cooled aero-engine by air at atmospheric temperature may at first sight appear a comparatively simple problem, but considerable development work has been necessary to arrive at the present stage of efficiency. An air-cooled engine has to rely on direct cooling by air at ambient temperature. Unless a fan is fitted behind the propeller spinner, the speed of air is governed by the slipstream, and this obviously varies according to the speed of the aircraft. It will become apparent that great care is necessary when ground running the engine to prevent overheating. To assist in cooling, the nose of the aircraft must face into wind.
6. The greater frontal area of a radial air-cooled engine necessitates careful attention to the design of cowlings and baffles to reduce the resultant drag, while at the same time ensuring satisfactory heat dissipation over the whole area of the cylinders and crankcase at various air speed and power outputs.
7. Although there has been a great increase in the power output of air-cooled engines, the proportion of power required to overcome the cooling drag has, with improvements in the technique of cooling, been maintained below 5% of the brake horse power. Developments have not only been in improved methods of heat dissipation, but also in connection with the reduction of aerodynamic losses by improvements in ducting and cowlings.
8. Any increase in power output of an air-cooled engine entails an increase in the amount of cooling surface necessary, and careful consideration of the heat dissipation properties of the various metals used; aluminium, copper and steel are generally considered the most suitable. An increase in power output will also necessitate an increase in velocity of the cooling air over the fins and invariably an increase in the allowable working temperatures.

Cooling Fins

9. The dissipation of heat from an air-cooled engine is accomplished by dispersing the heat from the cylinders to fins machined on the barrels and heads, and then arranging for the cooling air to pass over and between the fins and absorb the waste heat (Fig 1.6.1). The pitch and fin area of the cylinders must be such that the largest fin area can be obtained, but the fins must not be so close that their resistance to airflow builds up a pressure. The fins are thin in section and are extended to increase the fin area at local hot points to try to produce an even temperature throughout components. This is done, for example, on the exhaust ports of cylinders.

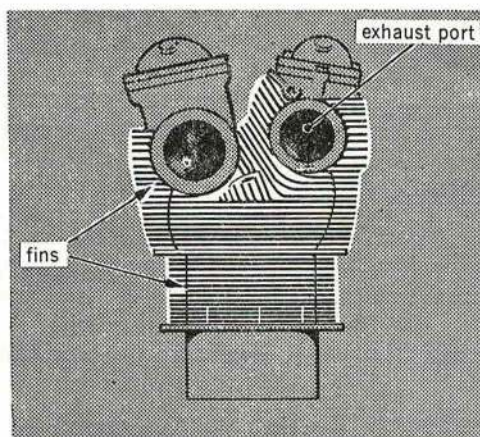


Fig 1.6.1 Cooling fins

10. **Servicing of cooling fins.** The fins should be examined to make sure that they are not cracked or broken, and reference should be made to the appropriate engine AP Volume 6 for limitations regarding repair. Generally, however, repair of damage to fins on the barrel is limited to small dents which must be carefully blended by lightly filing as near as possible to the original contour of the fins. On other fins, permissible damage is one half of one square inch on any one fin, and generally no more than three damaged fins are permissible on any one cylinder. Repair of damage to the shrunk flange is limited to dents, provided careful blending is carried out on the contour of the flange. The appropriate Volume 6 Air Publication shows the cylinder head and barrel divided diagrammatically into zones, and specific

instructions are given regarding the number of fins and the amounts of fin area that may be removed. A protective coating should be applied to the repaired area.

11. Fins and cylinder barrels should be kept free from dirt and oil as any build up will result in a loss of cooling efficiency.

Cooling Baffles (Inter-cylinder Baffles)

12. Cooling baffles are fitted to the cylinder barrels and heads of cylinders to direct the air flow to the required points and, consequently, assist the dissipation of heat to obtain uniform cylinder temperature characteristics. The baffles also assist in the reduction of drag because, during the design stage, care is taken to maintain an even cross-sectional area to the air duct so that the air flow does not decrease its speed from inlet to outlet. It is known that the shape of the baffles influences the heat dissipation characteristics very considerably, and the closer the baffles are to the fins, the better is the performance (Fig 1.6.2). The shape of the baffles must be such that there are no bottlenecks or sudden expansion in the passages formed by the baffles, fins and cylinders, and the baffle exit must not create turbulence.

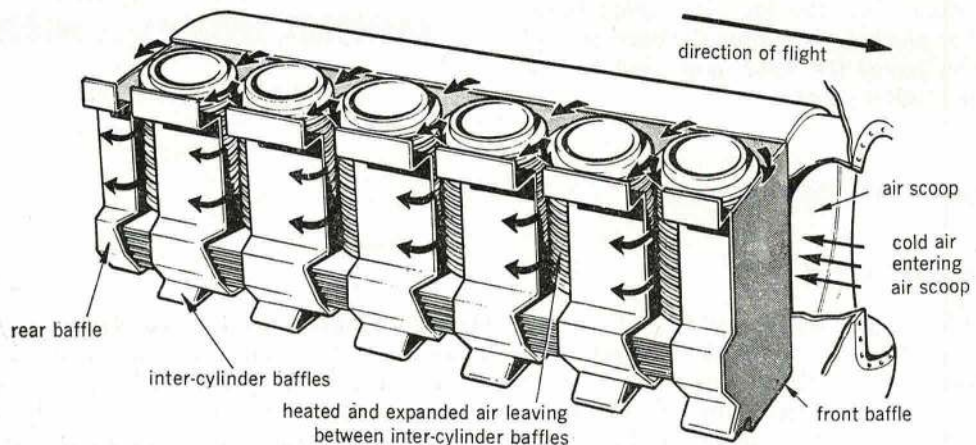


Fig 1.6.2 Cooling baffles

13. **Servicing of cooling baffles.** The cooling baffles or inter-cylinder baffles are usually made of steel or light alloy and are of comparatively light gauge. Care must, therefore, be taken when removing them from the engine to avoid bending or twisting them, as any distortion will prevent re-assembly. After cleaning, they should be examined for cracks and any signs of chafing against the cylinders. The riveting, wire clamps, securing pins and/or quick release units should be examined. Any rubber or composition should also be examined, particularly for deterioration. If any repairs are carried out, a protective coating should be applied to the repaired area.

Cowlings

14. Cowlings must be close fitting and without dents or projecting edges. Any disturbance of the air flow will cause drag and, therefore, decrease the cooling efficiency. Cowlings are generally fabricated from light alloy and are anodically treated to prevent corrosion. They must be examined for cracks, dents and damaged cowling fasteners. Care must be exercised in handling cowlings and, when removed, must be carefully placed so that the surface finish is not damaged.

Controllable Cowling Gills

15. On some radial engines, the air flow through the engine cylinders is controlled by gills which are opened and closed by an electrically-driven motor connected to sprockets and an endless chain (Fig 1.6.3). With the gills open, the airflow over the nacelle causes a pressure drop at the cooling air outlet, therefore making it easier for the cooling air to flow and maintain a high speed over the engine.

16. **Servicing of cowling gills.** When dismantling the gill plates from the levers, do not force the plates as this will cause cracking of the levers. Examine the plates, particularly for cracks and signs of fretting in the lever slots. Examine the plate catch bolts, and the sprockets (including the bearings and sprocket teeth) for wear, and examine the rubber chafing strips.

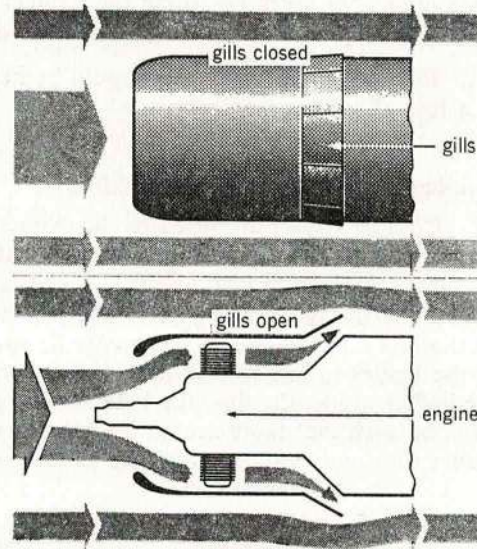


Fig 1.6.3 Cowling gills

LIQUID COOLED ENGINES

Liquid Cooling System

17. Although there are few aircraft in the Service today fitted with liquid cooled engines, background knowledge of this subject will give you an appreciation of what liquid cooling is, and why a pressurized system was introduced. With a simple open-vented thermo-syphon coolant system, the term 'open' meant that the system was open to atmosphere and, therefore, operated at ambient temperature. This system was reasonably satisfactory for aircraft with a comparatively low ceiling. But with the advent of high altitude flying it was necessary to introduce a system that would alleviate the limitations of a low boiling point system; therefore, a high pressure closed system had to be introduced to prevent boiling. Briefly, the disadvantages of a thermo-syphon system were:

- a. Too great a weight of coolant would be necessary to compensate for losses.
- b. As the aircraft climbed, the pressure drop acting on the coolant would lower its boiling point, thus producing too low a coolant temperature for efficient running and a high coolant loss because of evaporation.

18. The pressure system is closed and is self-pressurized by coolant expansion and the generation of vapour pressure in the air space within the system. A double acting release valve is provided at the highest point in the system (the header tank) to maintain correct working pressure. This valve is thermostatically controlled and vents to atmosphere without excessive coolant loss and relieves any depression within the system as the temperature of the coolant falls. The lowest pressure is at the pump inlet and the highest temperature is at the cylinder outlets, and these are the points where the tendency to boil is the greatest. Consequently, the essential conditions for safe and efficient functioning is that the combination of pressures and temperatures at these two points shall exceed by a safe margin those at which the coolant will boil.

19. Briefly the advantages of a pressure system are:

- a. The boiling point of the coolant is raised so that the liquid can act as a coolant up to higher temperatures; this allows the engine to run hotter and, therefore, more efficiently.
- b. A constant temperature is more easily maintained.
- c. An external pressure drop at altitude does not affect the internal pressurized system, nor hence, the boiling point of the coolant.

Coolant Circulation

20. Coolant is usually circulated in either a 'normal' or a 'shunt' system. With the normal coolant system, the coolant flows from the coolant pump outlet to the engine, through the header tank and radiator, and then to the coolant pump inlet (Fig 1.6.4).

21. The shunt system (Fig 1.6.4) is a development of the normal system and is arranged in two inter-dependent circuits, main and shunt. The main circuit flow is from the coolant pump outlet to the engine and then to the vapour separator, radiator, and coolant pump inlet in that order.

22. The shunt flow passes from the vapour separator to the header tank and then direct to the venturi at the coolant pump inlet. The object of the shunt flow is to break down the depression at the coolant pump inlet due to restriction at the radiator and to remove vapour from the coolant and so assist in preventing cavitation.

23. The shunt system also ensures that there is a small constant flow of coolant through the header tank, thus maintaining the reservoir at an even temperature. In addition, due to decreased coolant expansion, a smaller header tank may be used, and less coolant is necessary than for the normal system.

Components in a Cooler System

24. We shall now discuss the purposes of the components fitted to a liquid cooling system, the servicing involved and the safety precautions which must be taken when handling coolant.

Header Tanks

25. The header tank forms an expansion chamber and reservoir for the cooling fluid and may also act as a vapour separator. Header tanks are usually made of brass sheet with soft soldered seams, stiffened with mounting flanges, patch plates and internal bellows.

26. To separate steam and vapour from the hot coolant, swirl pipes or centrifugers are fitted in the tank joining the inlet to the outlet. These pipes are in the form of a volute with small holes drilled in the inside wall of the volute. As the hot coolant passes through the pipe,

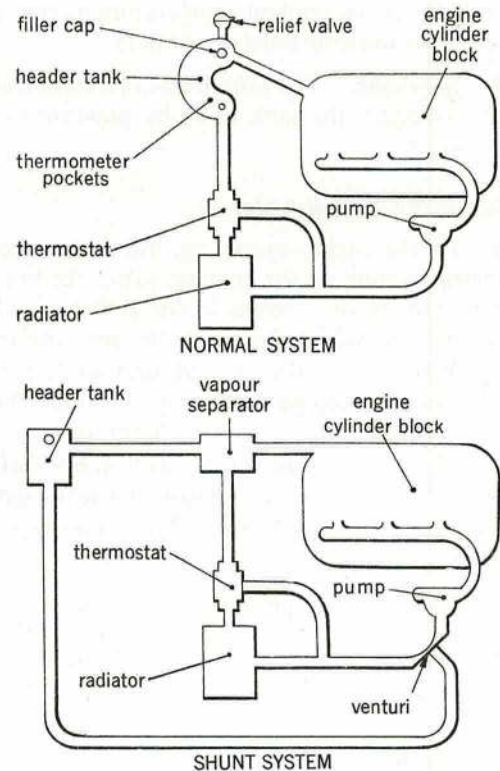


Fig 1.6.4 Coolant circulation—normal and shunt type systems

centrifugal action throws the heavy coolant against the outer wall of the volute and allows the vapour or steam to escape through the small holes in the inner wall.

27. A filler cap, complete with sealing washer and safety chain, is so fitted that it is impossible to overfill the tank. To prevent burns from hot coolant, no attempt should be made to remove the filler cap unless the coolant temperature is below 60°C.

28. One or more thermometer pockets are fitted in the header tank: one will be used for the bulb of the coolant temperature gauge; another pocket may be used for the thermostatic control of radiator flaps or shutters.

29. **Servicing.** The tank should be examined for leaks and insecurity of attachment. If leaks are suspected, the tank must be pressure tested in accordance with the relevant engine Air Publication.

Header Tank Relief Valves

30. As the engine warms up, the vapour from the coolant raises the pressure in the tank. This pressure, acting on the coolant, raises the boiling point and permits a higher temperature difference between the coolant in the radiator and the airstream, giving faster heat dissipation. The header tank relief valve limits the pressure in the header tank in the following manner:

- a. When the engine is cold, and while it is warming up to 100°C, the valve will vent any pressure exceeding 8 to 10 psi (approx 0.689 bars) to atmosphere.
- b. At temperatures above 100°C, the valve will blow off at a pressure of approximately 30 psi (2.068 bars) and will act as a safety valve.
- c. As the engine cools down, the valve will allow air to enter the system when the pressure falls to less than $2\frac{1}{2}$ psi below atmospheric pressure. This will prevent a vacuum forming and a possible collapse of the tank.

31. The valve assembly is sealed and must be replaced with a serviceable unit if suspect. To check the valve before installation, gently push in the valve till a restriction is felt and then release it. The valve should move in approximately $\frac{3}{8}$ in and, when released, should move back to its original position immediately. Excess movement indicates a faulty unit.

Thermostats

32. The thermostat is fitted into the coolant system in front of the radiator. It is a two-way valve which controls the by-pass of coolant round the radiator and is sensitive to the temperature of the coolant. By controlling the flow around the radiator, the thermostat will:

- a. Give a quick warm-up period.
- b. Control the minimum temperature of the coolant once the engine has reached normal temperature.

33. The thermostat is made up of three units as shown in Fig 1.6.5:

- a. The thermal bellows and valve assembly.
- b. The compensating bellows.
- c. The safety device.

34. The valve assembly consists of a poppet radiator valve which controls the passage of the coolant to the radiator, and a sleeve valve which controls the passage of the coolant to the radiator by-pass (see Fig 1.6.3). The valves are secured to a thermal bellows and are so arranged that, if either valve closes, the other will open. The thermal bellows are filled with a low boiling point fluid; therefore, with a cold engine, the radiator valve is kept closed by the contracted bellows and the by-pass is open. As the engine warms up, at a temperature of about 85°C, the

pressure in the bellows will cause it to expand, gradually closing the by-pass valve until, at approximately 105°C, the radiator valve will be fully open and the by-pass valve fully closed. All coolant will now pass through the radiator. The reverse action will take place as the engine cools.

35. The compensating bellows are fitted to neutralize the affect on the thermal bellows of any change of pressure on the coolant system and the safety bellows ensure that, with a faulty unit, the radiator valve is opened, and all coolant is fed through the radiator.

36. Where the engine warms up slowly, or if wide variations of coolant temperature are reported, the thermostat may be faulty. This may be checked by draining the system, removing the by-pass pipeline and observing the position of the valve. The by-pass valve should be partially open. If the valve is closed, the thermostat must be changed. A further check may be made if the by-pass valve is partially open, by placing the thermostat in water and then heating the water to above 85°C. If the by-pass valve begins to open at a lower temperature than 85°C, the compensating bellows has failed. The water must be agitated during this process to ensure an even temperature of the water. A replacement thermostat should be checked to ensure that the radiator valve is fully closed and that the by-pass valve is fully open.

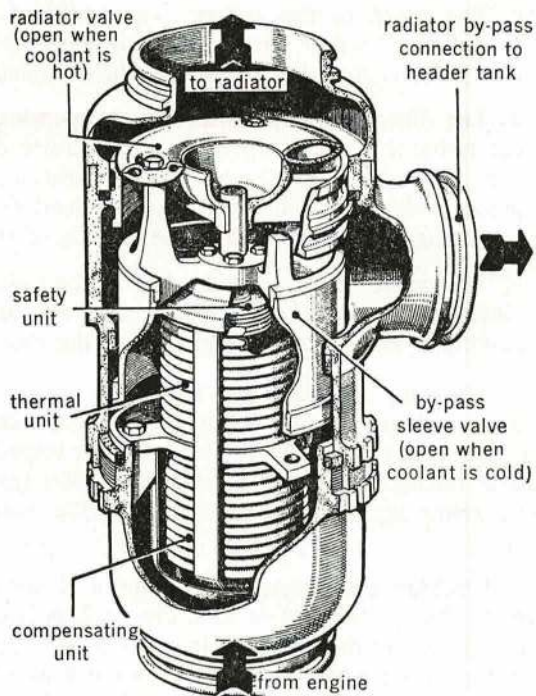


Fig 1.6.5 Thermostat

37. Where the engine warms up slowly, or if wide variations of coolant temperature are reported, the thermostat may be faulty. This may be checked by draining the system, removing the by-pass pipeline and observing the position of the valve. The by-pass valve should be partially open. If the valve is closed, the thermostat must be changed. A further check may be made if the by-pass valve is partially open, by placing the thermostat in water and then heating the water to above 85°C. If the by-pass valve begins to open at a lower temperature than 85°C, the compensating bellows has failed. The water must be agitated during this process to ensure an even temperature of the water. A replacement thermostat should be checked to ensure that the radiator valve is fully closed and that the by-pass valve is fully open.

Radiators

37. A radiator is used to dissipate to the atmosphere the excess heat absorbed by the engine. The radiator consists of a block of thin-walled metal tubes through which the coolant is passed. The heated tubes are then cooled by the air flow.

38. The rate of heat loss from a coolant will depend on a number of factors, including:

a. **The area of the tubes in contact with the airstream.** The area of the tubes in contact with the radiator is limited by the size of the radiator. Radiators are designed to give adequate cooling when the aircraft is climbing at maximum rate—engines have the greatest tendency to overheat at this point. In level flight and under cruising conditions, such a radiator will be too large.

b. **The rate of flow of coolant through the tubes.** The rate of coolant flow is basically controlled by engine speed, but part of the flow may be by-passed by the thermostat during engine warm up, or when cruising at low power. The flow is also affected by any sludge or dirt blocking the tubes. It is essential that great care be taken to mix coolant in clean containers and to filter the coolant. Radiators in store should always be suitably blanked to prevent ingress of dirt.

c. **The speed of the airflow.** The speed of the air depends on the slipstream from the propeller. The flow can be severely affected by dirt between the tubes and by bent fins in the radiator. Any deflection from the designed flow will reduce the efficiency of the radiator.

d. **The difference between coolant temperature and air temperature.** The heat flow across the radiator depends upon the temperature difference between the air and the coolant. The use of a pressurized system, with its higher coolant boiling point, will allow a greater temperature difference and give a greater heat flow. The efficiency of a radiator also varies with local climatic conditions and the altitude of the aircraft.

e. **The metals used in construction of the radiator.** The metals generally used in the manufacture of radiators are copper and brass because of their good heat conductivity qualities combined with ductility. This makes the radiator weighty and difficult to handle.

39. **Servicing of radiators.** Radiators are examined during normal routine servicing of the coolant system for leaks and insecurity of attachment. Great care must be taken to ensure that the flow of air through the matrix is not impeded by ingress of dirt. If necessary, blow the matrix through with compressed air *against* the normal air flow. Care must also be exercised when removing small obstructions from the matrix to prevent damage to the fins or corrugations.

40. **Flushing a radiator.** If a radiator requires flushing because of suspected sludge then it may be flushed through *in situ*. The coolant is drained and the inlet and outlet connections on the radiator are disconnected to allow a flushing rig to be fitted. The flushing medium is water and a cleaning agent, and the radiator is flushed *against* the normal direction of flow. The flow should be fed slowly at first and gradually increased to not less than 50 galls/min. The rig is then removed, the flushing medium drained from the radiator, and the normal connections remade. A pressure test of the system is then carried out in accordance with Servicing Procedures (SPs).

41. If more stringent tests are required, the radiator must be removed, cleaned and dried out ready for return to the manufacturer. Blanks must be fitted to all apertures and the equipment label attached giving the reasons for return to manufacturer. Radiators are transported in special containers. Great care must always be taken to prevent damage to the matrix and they must never be lifted by stub pipes or connections.

The Coolant Pump

42. The coolant pump is a centrifugal type with the rotor shaft and casing made of materials that are resistant to corrosion (Fig 1.6.6). The rotor shaft is supported in ball bearings that are isolated from the coolant by a packless gland. End thrust on the bearings is reduced by holes drilled through the rotor.

43. The packless gland is formed by two expanding bellows—one to prevent oil leakage past the bearings, and the other to prevent coolant leakage along the rotor shaft. Any seepage past either gland is fed to a common drain chamber, the drain passage of which must be kept clear. Leakage at this drain outlet indicates a faulty seal, and if the leakage is excessive, the pump must be replaced. If, however, a replacement pump is not available, the pump is removed; repairs can then be carried out to the gland seating, and the packless gland can be replaced.

44. Scores on the gland ring seating face are polished out with a very fine grinding paste, the face being kept square with the axis of the gland. Scores on the face of the carbon ring are removed, using a lapping tool as illustrated at Fig 1.6.7a. Before the pump is re-assembled, it will be necessary to check the side clearance of the rotor in the pump casing (Fig 1.6.7b). The

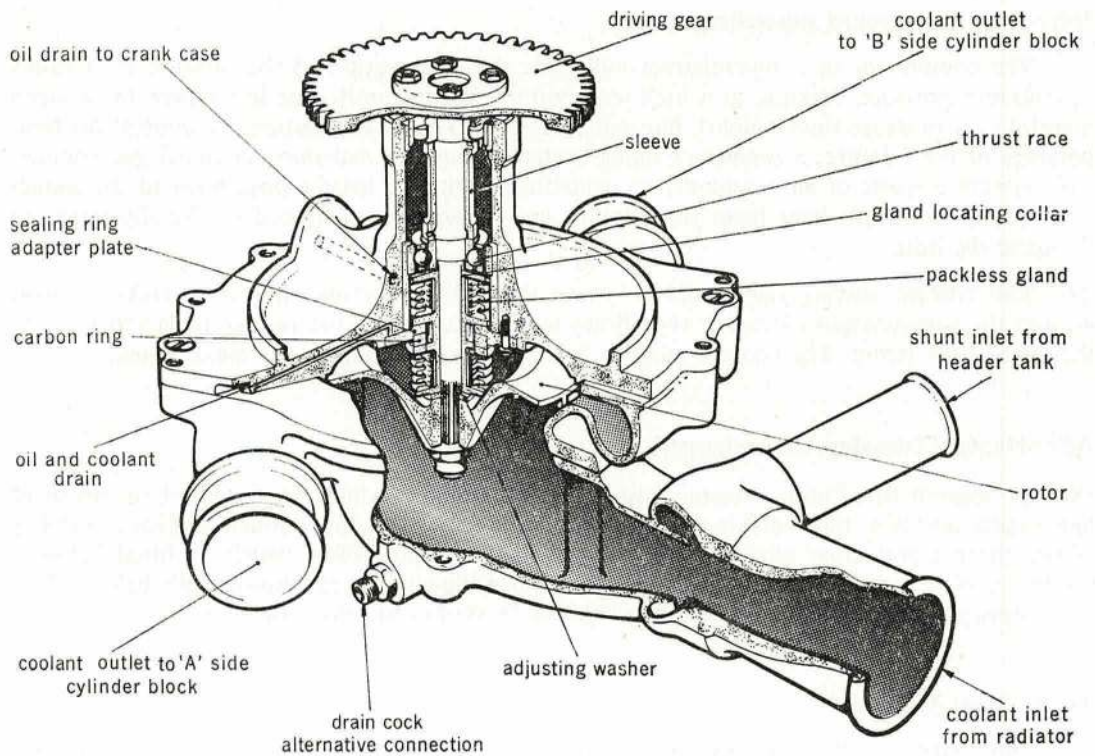


Fig 1.6.6 Coolant pump

clearances can be corrected by varying the thickness of the shims between the rotor and the packless gland. During assembly the rubbing faces of the carbon ring are lubricated with coolant. *Oil or grease must never be used in coolant systems or frothing of the coolant will occur.*

45. When replacing the pump, it is usual to fit the pump to the engine initially without the inlet casing, to make it easier to engage the shaft with the driving splines. When the pump is secured, the inlet casing is then fitted, pipelines are re-connected, the system refilled with coolant and a pressure test carried out.

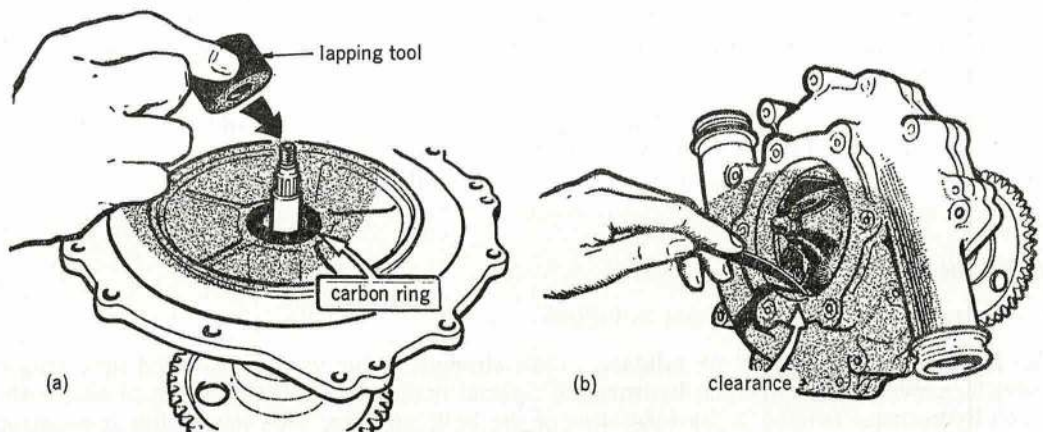


Fig 1.6.7 Using a lapping tool and checking rotor clearance

Intercooler (Two-speed supercharger)

46. The compressor of a supercharger will raise the temperature of the mixture as it raises the mixture pressure. Mixture at a high temperature will not only give less power for a given manifold air pressure (less weight), but will also tend to cause detonation. To control the temperature of the mixture, a *separate* cooling system is fitted to *two-stage* supercharged engines. This system consists of an engine-driven centrifugal pump, a matrix positioned in the induction system to absorb heat from the mixture and a radiator positioned in the slipstream to dissipate the heat.

47. The coolant leaving the pump passes to the radiator before entering a jacket formed around the supercharger casing. It then flows to the matrix and the header tank and back to the inlet of the pump. The coolant mixture is similar to that used in the main system.

After-Heater (Two-stage supercharger)

48. On aircraft fitted with *two-stage* supercharged engines, which are required to cruise at low engine rev/min, the fuel/air mixture temperature may fall low enough to give instability of the mixture and cause misfiring. To prevent this, an after-heater matrix is fitted between the intercooler and induction manifold so that, when the charge temperature falls below 40°C, a thermostatic valve permits coolant from the main system to reheat the charge.

The Coolant Mixture

49. The coolant used in the system is a mixture of ethylene-glycol and water. The normal proportions are 30/70, but additional ethylene-glycol can be added for arctic conditions. The addition of ethylene-glycol to water acts as an anti-freeze and prevents the system from freezing in a cold climate or when flying under conditions likely to produce freezing. It also raises the boiling point to above that of water. As ethylene-glycol tends to cause corrosion on light alloy components, inhibitors are added during manufacture to eliminate this trouble.

50. The efficiency of a liquid cooled aero-engine depends on the cleanliness of the system. Leaking radiators or coolant pipe joints, incorrect coolant level, or lack of cleanliness when mixing the coolant and filling the system may cause incorrect functioning.

51. When mixing the coolant, ordinary mains water may be used but, if the water is known to have a high chloride content, reference should be made to Engineering Orders. All apparatus used in the mixing of the coolant must be clean, and must be kept clean throughout the mixing and testing procedure.

52. Pour the required quantity of water into a clean container and add the inhibited ethylene-glycol AL3 (NATO Code No S735, Ref 24B/9100470) in the correct proportions. The glycol must be poured into the water *slowly* and the mixture constantly stirred.

Testing the Mixture

53. Two tests must be carried out as follows:

- a. **Testing specific gravity of mixture.** The strength of the mixture is tested by taking its specific gravity by means of a hydrometer. Special precautions must be taken to ensure that each hydrometer reading is representative of the bulk mixture. This precaution is necessary because of the possible variation in the purity of the ethylene-glycol when it is made up in

the proportion required. After making up the coolant mixture, it should be well stirred; a sample should be poured immediately into a clean glass and its specific gravity taken. The hydrometer reading must be taken at the base of the curve formed by the liquid on the stem of the float, and at the same time the temperature of the sample must be taken by a thermometer which is calibrated in degrees centigrade. The specific gravity reading must conform with the figures given on the graph which is illustrated at Fig 1.6.8. Comparison with the graph will indicate whether the mixture is correct relative to the temperature of the mixture. If the specific gravity is too low, glycol should be added to the mixture and repeated tests taken until it conforms with the graph. Should the specific gravity be too high, add more water to obtain the correct reading. The mixture should be well stirred before each test.

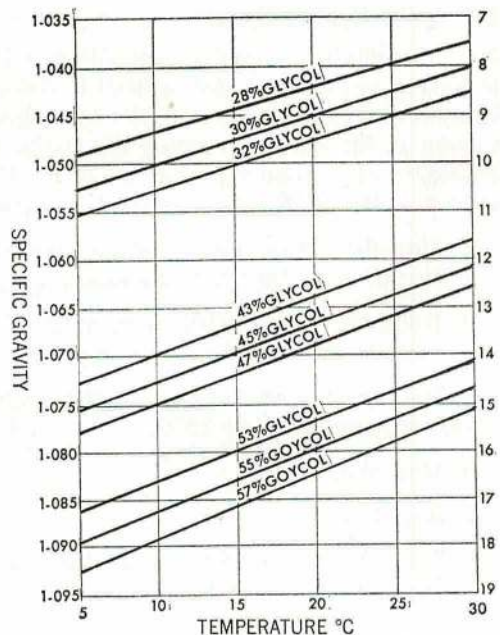


Fig 1.6.8 Specific gravity chart of coolant mixture

b. Testing the mixture for acidity. Test papers show a chemical reaction when inserted in the coolant mixture and are used to check that the ethylene-glycol is free from acid. The check should be made *before* and *after* the glycol has been mixed with the water and at specified periods as laid down in the Servicing Schedule or when the mixture is suspect. The test papers must be inserted in the coolant mixture, reaction commencing after 10 seconds and complete reaction taking place after 30 seconds. If the paper turns green, it indicates that the coolant is satisfactory, but if it turns purple or red, the coolant must be rejected. Should the latter condition arise with new coolant, the reason should be investigated. Should the coolant in a system in use be in a similar condition, the coolant is to be drained, the system flushed and refilled with new coolant. *Coolant which contains acid should be rejected and disposed of.*

Coolant in Use

54. During the period that the coolant is in service, the correct water/glycol mixture as indicated by the specific gravity must be maintained. Evaporation, resulting from high temperatures and prolonged use, will affect the strength of the coolant. Any evaporation that takes place is almost entirely that of water, and consequently the specific gravity of the mixture will tend to increase. Again, as in the case of acidity mentioned in the previous paragraph, the coolant is to be drained, the system flushed and refilled with clean coolant.

Topping up the System

55. Before each flight, the coolant level in the main and intercooler header tanks must be checked and sufficient tested coolant added to bring the coolant up to the correct level. *Do not add water only.* The loss of coolant under normal operating conditions should be small, and if more than four pints are required to restore the level in the main system, or more than two pints in the intercooler, the system should be examined for leaks.

Filling the Coolant System

56. The important points when filling a system are to make certain that the coolant mixture is correct and that the system itself is clean to accept the mixture. The system can be cleaned by adding a cleaning agent to the existing coolant mixture (45cc of cleaner to every gallon of coolant in the system), running the engine up to a temperature of 60°C and then opening up to 2000 rev/min and continue to run for 10 minutes, maintaining the engine temperature at approximately 90°C. Then proceed as follows:

- a. Stop the engine and allow the coolant temperature to drop to 60°C and then drain the system with the least possible delay.
- b. Refill the system with clean water, allowing the first few gallons to run straight through the system before replacing drain plugs.
- c. Start the engine and run at 2000 rev/min for approximately 5 minutes, keeping the coolant temperature below 80°C.
- d. Repeat a, b and c.
- e. Repeat a.
- f. Refill the system with new coolant, making sure that a flow of coolant free from air is passing through the vents.
- g. Refit and lock drain plugs.
- h. Refit filler caps.
- j. Ground run the engine for a short period at 1000 to 1200 rev/min in order to circulate the coolant and remove any air pockets in the system. Stop the engine before the temperature reaches 40°C and check the coolant level. Add coolant if necessary and replace the filler cap.

Pressure Testing the System

57. Aircraft coolant systems are pressure tested during normal periodic servicing, or when a pipeline or component in the system has been disturbed. Where possible, to reproduce running conditions, the test should take place with the coolant temperature of about 50°C.

58. A pressure gauge and Schrader valve are fitted and the header tank relief valve is blanked off. Air from a foot pump is fed through the Schrader valve to raise the pressure to 40 psi (2.76 bars). This pressure should not fall for at least ten minutes. If the pressure is not held and an external leak cannot be found then an internal coolant leak is possible. An illustration of the pressure testing of a coolant system is indicated at Fig 1.6.9.

Overheating

59. The main problem encountered in a coolant system will almost certainly be one of overheating. Abnormally high coolant temperatures may be caused by partial blockage in the system, such as furring of the matrix

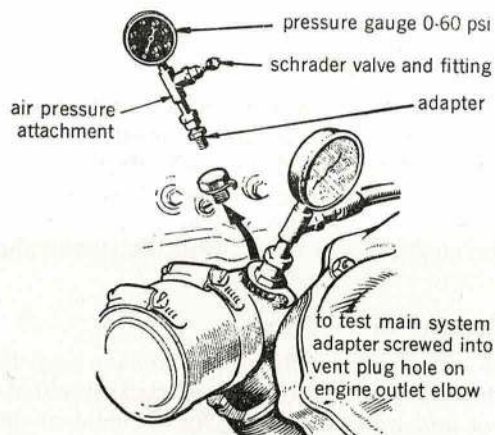


Fig 1.6.9 Pressure testing a coolant system

of the radiator, which will result in a drop in efficiency of the coolant system. If a high temperature is apparent, the radiator should be drained and a flow test carried out as detailed in Volume 1 of AP2850A (Aircraft Radiators and Oil Coolers).

60. High temperatures can also be caused by incorrect functioning of the thermostatic control or pressure relief valves or by corrosion in the header tank. If any of these components are suspect, they should be repaired or replaced. When radiator shutters are fitted, their operation should be checked in the fully open and fully closed positions.

61. Foaming results in the loss of the coolant through the release valve and this will quickly cause a rise in temperature, with consequent overheating and serious damage to the engine. Should there be any signs of this condition, the system must be drained, cleaned and refilled with new coolant. An internal coolant leak may be indicated by white puffs of smoke from the exhaust system.

Safety Precautions

62. Great care must be exercised when draining an engine cooling system to avoid getting splashed with the hot coolant, as serious scalding can easily occur. The resulting burns can be both painful and serious. Great care must be taken when releasing the filler cap on the header tank, unless the system is cool or cold, owing to the pressure developed in the system at operational temperatures. Do not fully unscrew the filler cap on the header tank until it is certain that all pressure has been released.

63. The fumes from the ethylene-glycol should not be inhaled. The glycol mixture has a deleterious effect on rubber and care must be taken to prevent spillage. Should the coolant be splashed on to any rubber components, such as tyres or electrical cables, they should be wiped dry immediately.

CONCLUSION

64. Air cooling is light and relatively cheap and little or no maintenance is required. However, because of the variables explained, it is difficult to keep the engine running at a constant temperature under all conditions, taking into account forward speed, engine throttle settings and temperature of the air. Liquid cooling, however, although expensive and more difficult to maintain, can hold the engine at a constant temperature. Also, by design, a liquid cooling system can be more easily streamlined and this produces less drag on the aircraft.



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