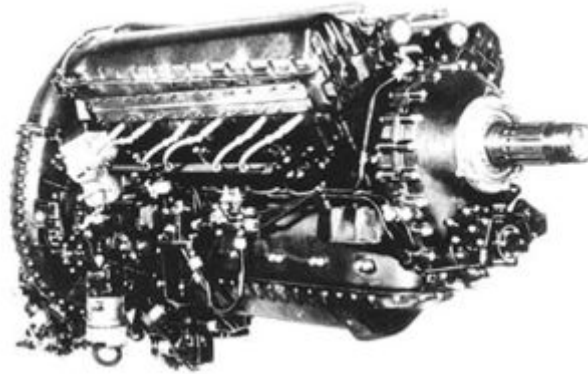


Rolls-Royce Merlin Aircraft Engine



The **Rolls-Royce Merlin** engines were a series of liquid cooled 27 litre (1649 in³) 60° V-12 piston aircraft engines built during World War II by Rolls-Royce (Derby, Crewe, and Glasgow), at Ford in Manchester and under licence in the United States by Packard. They are widely considered to be among the most successful aero engines produced during World War II, and perhaps the finest piston engines ever built for aviation. Merlins are highly sought-after by aviation enthusiasts even today. The Merlin name came from the bird.

History

In the early 1930s, Rolls started planning for the future of its aero engine development programs, and eventually settled on having two basic designs. The 700 horsepower Rolls-Royce Peregrine was an updated, supercharged development of their existing V-12, 22 L Rolls-Royce Kestrel which had been used with great success in a number of 1930s designs. Two Peregrines bolted together on a common crankshaft into an X-24 layout would create the 1,700 hp 44 L Rolls-Royce Vulture, for use in larger planes like bombers. There was also the possibility that the famous 36 L 'R' engine from the Supermarine racing planes could be developed into a 1,500 hp class engine of its own, itself a development of the Rolls-Royce Buzzard, a scaled up Kestrel.

However, this plan left a large gap between 700 and 1,500 hp. To fill the gap work was started on a new 1,100 hp class design as the *PV-12* – PV for "private venture" as the company received no government money for work on the project. The PV-12 first flew on the front of a Hawker Hart biplane in 1935, using the new evaporative cooling system then in vogue. The cooling system proved unreliable, and when supplies of ethylene glycol (Prestone) from the US became available, the engine was changed to the conventional liquid cooling system instead.

In 1936, the Air Ministry had a requirement for a new fighter aircraft with airspeeds that would eventually have to be over 300 mph. Fortunately, two designs had been developed entirely as private venture exercises: the Hawker Hurricane and Supermarine Spitfire. Both were designed around the PV-12 instead of the Kestrel, and were the only British modern fighters to have been so developed. Production contracts for both aircraft were let in 1936. The PV-12 was instantly catapulted to the top of the supply chain and became the Merlin. First widely delivered as the 1,030 hp Merlin II in 1938, production was quickly stepped up. The Merlin I had a 'ramp head' where the inlet valves were at a 45-degree angle to the cylinder. This was not a success and only 172 were made before the conventional flat head arrangement (valves parallel to the cylinder) was adopted for the Merlin II.

Early Merlins were considered to be rather unreliable, but Rolls-Royce soon introduced a superb reliability-improvement program to improve matters. This consisted of taking random engines from the end of assembly line and running them continuously at full power until they failed. Each was then dismantled to find out which part had failed, and that part was redesigned to be stronger. After two years of this, the Merlin had matured into one of the most reliable aero engines in the world, and could be run at full power for eight-hour bombing missions with no problems.

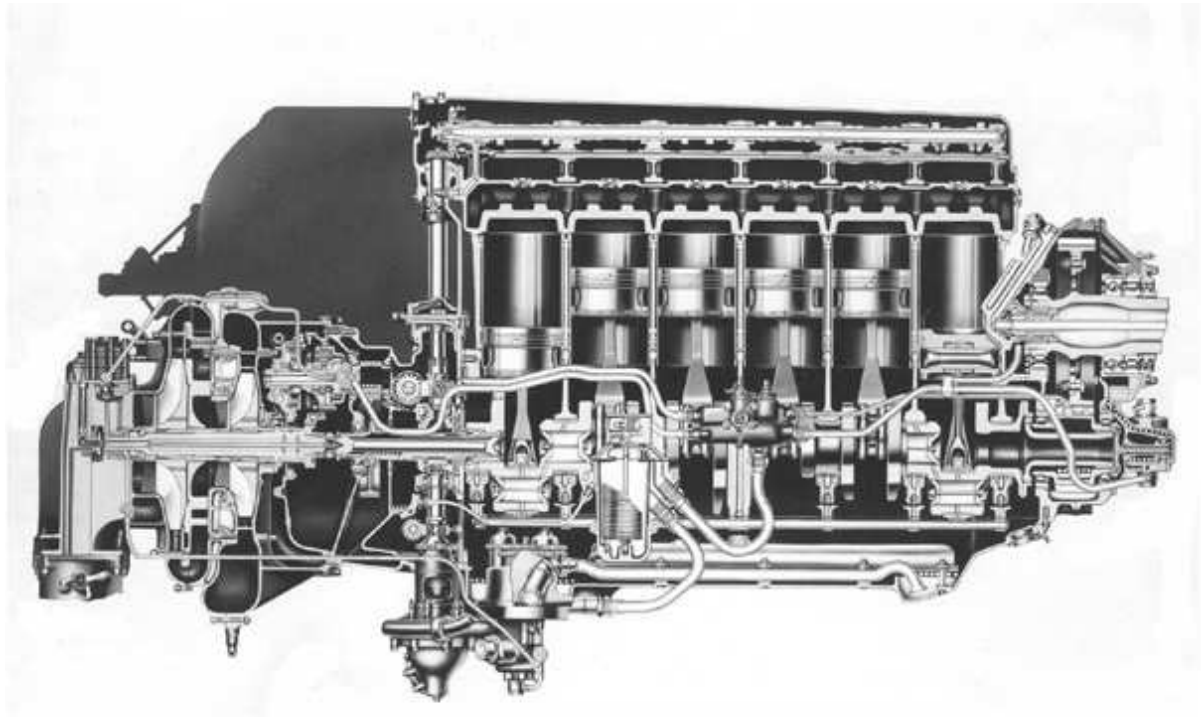
As it turned out, the Peregrine saw use in only two aircraft, the Westland Whirlwind and the Gloster F9/37. Although the Peregrine appeared to be a satisfactory design, it was never allowed to mature; Rolls-Royce's priority was troubleshooting the Merlin. The Vulture was fitted to the Hawker Tornado and Avro Manchester, but proved unreliable owing to failures of the crankshaft to connecting-rod bearing caused by lubrication problems. With the Merlin itself soon pushing into the 1,500 hp range, the Peregrine and Vulture were both cancelled in 1943.

By the end of its production run, over 150,000 Merlin engines had been built. It was supplanted in service by the Rolls-Royce Griffon which was a development of the R racing engine.

Most of the upgrades to the Merlin were the result of ever-increasing octane ratings in the aviation fuel available from the US, and ever more efficient supercharger designs. At the start of the war the engine ran on the then-standard 87 octane aviation spirit and could supply just over 1,000 hp from its 27 L displacement compared to 1,100 hp from the 34 L Daimler-Benz DB 601. From June 1940 small quantities of 100 octane fuel, imported from the U.S, became available and the Merlin IIIs were found to be capable of running

on it. The next major version was the XX which ran on 100 octane fuel. This allowed it to be run at higher manifold pressures, which were achieved by increasing the "boost" from the centrifugal type supercharger. The result was the otherwise similar engine delivered 1,300 hp. Another improvement made to the XX and future Merlin variants was a redesign of the cooling system to work using a 70/30% water/glycol mix rather than the 100% glycol of the Merlin Is, IIs, and IIIs. This allowed the engines to run some 70 degrees C cooler, substantially improving engine life and reliability. This also removed a potential fire hazard from Merlin powered aircraft, as pure ethylene glycol is a flammable liquid.

The process continued, with later versions running on further-increased octane ratings, delivering higher and higher power ratings. By the end of the war the "little" engine was delivering over 1,600 hp in common versions, and as much as 2,070 hp in the emergency situations. The Merlin was running on 150 Octane fuel by the time it was used in the Lancaster bomber. This high octane rating was achieved by large quantities of tetraethyl lead--so much in fact, the engine cowlings around the exhaust outlets were usually heavily stained with it. It had to be regularly removed for aerodynamic, not to mention weight, reasons.



Above left shows the side view of the internal 2 speed, 2 stage supercharger. Note the different diameters of the compression wheels. The engine supercharger cut-in at 19,000 feet, and off between 14,500 and 19,000 feet. The supercharger was automatic, but could be manually over ridden. In order to give the engine an extra burst of power during an emergency, the throttle could be pushed past the gate stop by breaking the safety wire. If used longer than five minutes, there was a risk of severe engine damage.

Mustang pilots were left in no doubt when the supercharger cut into the high-blower position, for the aircraft shuddered violently. They had to learn to anticipate the cut-in and reduce throttle. When descending, the change to low-blower took place at about 14,500 feet, and the only indication of the event was a drop in manifold pressure. The Packard Merlin drove either a four-blade Hamilton-Standard Hydromatic or Aeroproducts automatic, constant-speed propeller. Coolant (30/70 ethylene-glycol/water) and oil radiators were installed in the pronounced belly scoop radiator fairing under the fuselage.

One weakness of the Merlin was that it could be put out of action by a single bullet, or piece of shrapnel, but this applied to all liquid-cooled engines, and did not detract from the Mustang's all-round capabilities. The aircraft was a welcome sight to the Fortress crews as they plunged deep into German skies during the daylight offensive against the Nazi armament industries.

Carburetor Developments

The Merlin's lack of direct fuel injection meant both Spitfires and Hurricanes were, unlike the contemporary Bf-109E, unable to nose down into a deep dive. This meant the *Luftwaffe* fighters could 'bunt' into a high-power dive to escape attack, leaving the pursuing aircraft spluttering behind as its fuel was forced by negative 'g' out of the carburetor. RAF fighter pilots soon learned to 'half-roll' their aircraft before diving to pursue their opponents. The use of carburetors was calculated to give a higher specific power output, due to the lower temperature, and hence the greater density, of the fuel/air mixture, compared to injected systems. "Miss Shilling's orifice" (invented in March 1941 by Beatrice Shilling, an engineer at the Royal Aircraft Establishment, Farnborough), a holed diaphragm fitted across the float chambers, went some way towards curing the fuel starvation in a dive. Further improvements were introduced throughout the Merlins: 1943 saw the introduction of a Bendix-Stromburg carburetor which injected fuel at 5psi through a nozzle direct into the supercharger and was fitted to the Merlins 66, 70, 76, 77, and 85. The final development was an SU injection carburetor which injected fuel into the supercharger using a fuel pump driven as a function of crankshaft speed and engine pressures, which was fitted to the 100 series Merlins. Production of the Rolls- Royce Griffon-engined Spitfire Mk. XII had begun the year before.