



*- Fly Confident*

## PRECISION BULLETIN

In 1998, Pratt & Whitney re-issued Service Bulletin 1183 Rev U. In the letter, they approved the use of multi-graded oils in their radial engines. This approval was based on field evaluations run by the oil companies in commercial fleets. It should be noted that Service Bulletin 1183 does not recommend the use of Multi-grade oil on large radial engines. The preferred choice for moderate to warm climates is grade 120 and grade 100 for very cold climates. Since then, Precision Engines has noted an increase in master rod bearing wear and an increase in actual master rod bearing failures when large radial engines are operated on multi-grade oils in some non-fleet types of operation. Based on these results, Precision strongly recommends that all radial engines with a displacement of over 1800 cubic inches be operated only on single grade oils meeting the SAE J-1899/Mil-L-22851 for ashless dispersant oils, or SAE J-1966/MIL-L-6082 specification for straight mineral oil. This will apply to all engines presently in service as well as new installations. As per applicable recommendations from the manufacturers, our primary recommendations would be a grade 120 oil. A grade 100 oil qualified against the same specifications can be used in winter time operation if a thinner oil is required.

The master rod bearing in a radial engine presents two unique problems from a lubrication stand point. First is that all of the power from a row of cylinders is transmitted through the master rod bearing. The second concern is that the master rod bearing is always under a load.

Almost all internal combustion engines use plane bearings to transform the power from the pistons and connecting rods to the crankshaft. Plane bearings are just a flat surface or plane that surrounds the crankshaft journal. When oil is pressured into the space between the bearing surface and the crankshaft, the bearing surface is separated from the crankshaft journal surface by the oil. This is called hydro-dynamic lubrication. With hydrodynamic lubrication, the amount or oil film thickness at the time of a power pulse is controlled by the pressure on the oil to force it into the space available, the mechanical action of the bearing motion and the flow ability of the oil to exit or leak out of the bearing cavity.

In an inline, V, or opposed engine, each crankshaft journal bearing only transmits the power produced by that one piston. Therefore, in a 6 cylinder, 420 hp engine, each connecting rod bearing transmits only about 70 hp. (The main bearings do transmit higher

loads, but this is a pure rotation motion and not the reciprocating to rotation motion of the connecting rods.) The other positive for these types of engines is that in a four cycle engine, the connecting rod bearing is loaded and unloaded prior to every power pulse. This insures that the high load area of the bearing (that area closest to the piston) is completely filled with oil on the intake cycle. Then as the piston is forced inward on the compression stroke, and subsequent power stroke, the mechanical action in the bearing forces oil into the clearance between the bearing and the journal at the highest load point.

In a radial engine, all of the connecting rods for a single row are attached to the one master rod. This means that up to 1400 hp of reciprocation motion is transformed into rotation motion through one bearing. And the bearing is never completely unloaded. In a 9 cylinder engine, there is a power pulse every 80 degrees. This means that the mechanical action of the bearing has a reduced effect on the oil film thickness at the moment of the greatest load from a power pulse. Therefore the master rod bearing is more dependent on pressure and leak out rate from the bearing cavity.

When multi-grade oils are blended, they contain polymers that are complex chemical molecules that expand when heated and contract when cooled. Even semi-synthetic oils contain a certain level of polymers to meet the viscosity limits. With polymer containing oils there are two major differences from a single grade oil. They are permanent shear and temporary shear. When the viscosity of an oil is measured, the oil is cooled or heated to a prescribed temperature. Then the oil is poured through a thin tube and the time for a prescribe amount of oil to flow through the tube relates back to the viscosity of the oil. The problem is that the oil is not under any pressure. It is just a measurement of how fast it can be poured. In an actual engine, there can be a lot of pressure in some areas, like the master rod bearing and gear drives. These extreme pressures can break some of the polymer molecules which results in permanent loss of viscosity. In addition, under high pressures, much of the complex polymer molecule can be squeezed together resulting in a temporary viscosity loss. Thus a 15W-50 or 20W-50 will not act like a single grade 100 oil in the master rod bearing. NOTE, all ashless dispersant oils contain a small amount of polymer, but still have enough base oil viscosity to protect the master rod bearings.

One of the most significant advantages for multi-grade oils is their improved flow characteristics. This provides quicker lubrication upon start-up and improved flow at most operating conditions. One of the down-sides of the improved flow of multi-grade oils is when they are used in a radial engine, there is an increased amount of leakage compared to a single grade oil. If one considers that the oil film thickness in the bearing cavity is dependent on the leakage rate out of the bearing cavity, then it follows that the multi-grade oil will provide less of a margin of safety than a single grade oil, in the master rod bearing.

In fleet operation, the aircraft are normally flown very much by the book. This means prescribed take offs, smooth transitions to cruise and then to descent, and no sharp power changes or reverse loading. However, for war birds and some other non-fleet aircraft, the power may be changed abruptly or reverse loading can occur. This greatly increases the loading on the master rod bearing momentarily. When a multi-grade oil is used and these changes occur, the load on the master rod can force all of the oil film out of the clearance

between the bearing and the journal. When this happens, the bearing material can make metal to metal contact with the crankshaft surface. This will start to hammer the soft bearing material which will increase the bearing clearance. When the bearing clearance is increased, the amount of oil leakage out of the bearing cavity is increased even further and the wear process accelerates until failure can occur. By comparison, a thicker based oil such as a grade 120, greatly reduces the leakage rate out of the bearing cavity. Which in turn results in less wear and an increase margin of safety for the master rod bearing.

Another concern with multi-grade oils is their temperature vs. viscosity characteristics compared to single grade oils. The viscosity of a 15w/50 or 20w/50 is similar to that of a single grade 100 oil at 100C. However; most large radial engines run oil temperatures in the 80 to 90C range. At this temperature, a single grade 100 oil will be 20 to 30% thicker than a 15W/50 or 20W/50.

Multi-grade oils can provide a distinct advantage during cold weather starting and operations. However; based on tear-down and pre-mature engine failure reports available to date plus the physical property characteristics of the oils, Precision Engines feel very strongly that an approved single grade 120 provides the best margin of safety and will provide the best chance for your engines to reach TBO.