FLUID POWER
Design Data Sheet

Womack Machine Supply Co.

Revised Sheet 29 - Womack Design Data File

LIFE EXPECTANCY OF PISTON-TYPE HYDRAULIC PUMPS & MOTORS

Information in this issue applies only to piston-type hydraulic pumps and motors. Additional information on gear and vane-type pumps and motors will be presented in a later issue. Most of the information applies to both pumps and hydraulic motors, but for the sake of convenience, the term "pump" will be used throughout.

Pump Life

When selecting a hydraulic pump for a specific application, a designer should arrive at a good balance between cost of the pump and its expected life. Every pump has a certain number of "operating hours" built into it, and when these hours are "used up", the pump can be expected to fail, and must be replaced. The number of operating hours built into a pump is directly related to its cost, and the user gets pretty much just what he pays for.

"Cheap'' pumps are designed for applications where the anticipated pump life will equal or surpass the operating life of the machine on which the pump is used. It would be unwise to purchase an expensive pump for these applications. But on machines designed to operate reliably for many years, or in situations where a pump breakdown would be very costly in terms of lost time or production output, it would be foolish to purchase a "cheap" pump. On these applications, a better quality pump should be selected, and while such a pump would cost more, it would save a great deal of money during the life of the machine.

It is the purpose of this sheet to consider the factors which influence pump life, to aid the designer to make a good balance between pump cost and life expectancy.

Life Rating on a Pump

To use the information in this data sheet, the pump manufacturer should be required to furnish a life rating for the pump under consideration. This will be a statement of expected operating hours at a pressure of (so many) PSI, and a speed of (so many) RPM. This information is based on shaft bearing life expectancy, and is as far as the manufacturer can go. The rest is up to the designer, and it is his responsibility to see that circuit conditions which prolong pump life are observed. These are enumerated on the back side of this sheet.

These two factors have the greatest influence on shaft bearing life:

1. **Speed.** Bearing life is in approximate inverse proportion to shaft RPM. For example, by reducing shaft speed to one-half, pump life expectancy is doubled.

2. **Pressure.** Pump life varies inversely as the cube of side load on the shaft bearing, and this is directly related to hydraulic pressure, PSI, on the pump outlet port.

For example: If system pressure is reduced to one-half, bearing life will be increased by the cube of 2, or 8 times.

Another example: If system pressure were to be raised from 4,000 to 5,000 PSI, a factor of 1.25 times original pressure, bearing life would be reduced by the cube of 1.25, or by 51%.

Therefore, to increase life expectancy, both **speed** and **pressure** must be kept to moderate values.

Life Expenditure of a Pump

Life of a pump, based on bearing life expectancy, is figured on the actual time during which the pump is running at the pressure and speed on which the rating is based. The time during which the pump is running unloaded or at, say less than half rated pressure, as when advancing or retracting a cylinder, is not counted as life expenditure. For example, if pump life rating is 3,000 hours, this means 3,000 hours running under manufacturer's specified conditions.

Estimating Pump Life Expenditure

Example: Calculate the number of hours expended in the life of a pump over a year's operation consisting of 8 hours a day, 252 days per year, if the pump is operating on a duty cycle of 5 seconds under full pressure, followed by 25 seconds running unloaded or at low pressure advance and retract of a cylinder.

Solution: Each cycle is 5 + 25 = 30 seconds. Life expenditure each cycle is 5 ÷ 20 = 0.167 or 16.7% of total running time.

Running time in a year is 8 × 252 = 2,016 hours, of which 16.7% is life expenditure. Pump life used up in a year's operation is 2,016 × 0.167 = 336.67 hours.

Manufacturer's Life Rating

As previously stated, the life rating of any pump can be obtained from the Engineering Department of its manufacturer. This will be stated as (so many) hours operation at a stated pressure and speed. This rating can then be adjusted for other speeds and pressures following the rules already given which pertain to speed and pressure.

Example: A certain piston pump is rated for operation at speeds to 3,000 RPM and pressures to 5,000 PSI. These are catalog maximums. But its rated life is 10,000 hours at 2,000 RPM and 3,000 PSI. Find its life expectancy at other speeds and pressures.

The chart below has been calculated for this particular pump using the rules previously stated:

Operating Pressure PSI	1000 RPM	1500 RPM	2000 RPM	2500 RPM	3000 RPM
2,000	67,500	45,000	33,750	27,000	22,500
3,000	20,000	13,333	10,000	8,000	6,667
4,000	8,440	5,625	4,220	3,375	2,815
5,000	4,320	2,880	2,160	1,725	1,440

The chart shows that pump life will be reduced to 1,440 hours if operated simultaneously at maximum pressure and maximum speed. But if run at reduced conditions of 2,000 PSI and 1,000 RPM, it would have the fantastic life rating of 67,500 hours. Similar charts can be prepared for any pump.

CHECKLIST
Factors Which Affect Pump Life

The factors affecting pump life listed on this page will serve as a checklist. Most of them are well known to designers and do not need lengthy comment.

If circuit conditions are otherwise ideal, most piston pump (and motor) failures are because the shaft bearings have reached the end of their natural life. The pump manufacturer has stated the expected bearing life under specified conditions of speed and pressure. Beyond this, he has no control of operating conditions in the system. It is then up to the system designer to provide favorable operating conditions. If he does not, then it is not the fault of the pump if it prematurely and unexpectedly fails. For maximum pump life the following factors should be considered:

1. **Oil cleanliness.** Oil filtration should not be limited to a 150 µM pump suction strainer, but should also include a pressure or return line filter of 10 µM rating or better. Recent tests have shown that by using a filter of 3 µM absolute rating rather than 10 µM, pump life is significantly increased. Whether to go to the expense of extra fine filtration depends on how much it will cost to replace the pump, and how much a production shutdown may cost while the pump is being replaced.

2. **Side Load on the Pump Shaft.** No matter whether or not the pump is catalog-rated for shaft load, any appreciable side or end load will always reduce pump bearing life to some extent. No general rules can be given for the effect of these shaft loads; this information must be obtained from the pump manufacturer. On some applications the natural life of the bearings is so long that additional side or end loading can be tolerated and a satisfactory pump life still obtained.

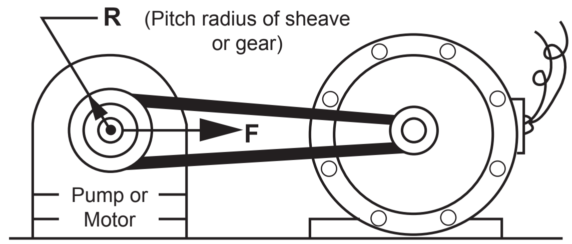
   To minimize side load against the shaft, observe these rules when installing pumps with side drive:

   a. Mount the gear or sheave on the pump shaft as close as possible to the front face of the pump case, and install with hub facing AWAY from pump case, to reduce the amount of flexing or bending of the shaft.

   b. The gears or sheaves on the pump shaft should be of as large diameter as practical. The larger the diameter, the less the side load at the same torque.

How to Calculate
Side Load on Hydraulic Pump or Motor Shaft

Use these formulae to be sure manufacturer's shaft side load rating will not be exceeded.



For pump: F = [HP × 63,024] ÷ [RPM × R]
For hydraulic motor: F = T/R

*In these formulae, **F** is side load in lbs;*
***T** is torque in inch-lbs;*
***R** is sheave or gear pitch radius in inches.*

3. **Oil Temperature.** The harmful effects of excessive oil temperature are pretty well known. Heat produces contamination, premature wear or degeneration of rubber seals, excessive mechanical wear in the pump, etc. Where possible, oil temperature should be controlled with a heat exchanger if necessary.

4. **Cavitation.** The harmful effects of pump inlet cavitation are also pretty well known - pump wear due to wire drawing, mechanical wear, heat, etc. The next chart shows the maximum inlet vacuum which is permitted by most pump manufacturers:

	Gear Pumps	Vane Pumps	Piston Pumps
Vacuum, PSI	3 to 5	2 to 3	2
Vacuum, In. Hg.	6 to 10	4 to 6	4

5. **Misalignment of Pump Shaft.** When direct-driving a pump from an engine or electric motor shaft, even a small amount of uncorrected misalignment can very quickly ruin the pump bearings. The obvious remedy here is to very carefully align the two shafts.

6. **Pump Relief Valve.** The relief valve, especially in systems using a series-connected flow control valve, should be set to the lowest relieving pressure which will serve the circuit. Excessive pressure, during the feed cycle, reduces pump life. When using pressure compensated pumps, unload them to near zero pressure in valve neutral rather than deadheading them to zero flow at maximum pressure. Operation at maximum pressure, even though not pumping a flow of oil, counts as running time when estimating pump life. With fixed displacement pumps, they should be unloaded to low pressure when the system is not actively working.

Published by:
WOMACK EDUCATIONAL PUBLICATIONS
Womack Machine Supply Co.
13835 Senlac Dr.
Farmers Branch, TX 75234
Tel: 800-859-9801 Fax: 214-630-5314
www.womack-educational.com