Southwest Oilfield Products offers upgraded fluid ends for popular mud pumps that allow operation at 7,500 PSI maximum working pressure. Sometimes there are concerns that the upgraded fluid ends operation at 7,500 PSI will impose extra loads on the power frame. This paper will discuss the various loads imposed on the power frame and how they are calculated. The loads imposed on the power frame are rod load, liner reaction load, and weight of the fluid end. Valve sizes used in Southwest 7,500 PSI fluid ends will be briefly discussed as well.

Rod Load

Mud pump power ends are rated according to their horsepower capability. The amount of horsepower that a power end is capable of handling is determined by the components of the power end such as connecting rod bearings, wrist pin bearings, crossheads, main bearings, and crosshead extension rods (pony rods)/piston rods as well as the crankshaft and power frame itself. Horsepower is the rate at which work is done. Work is done in a mud pump when drilling fluid is moved by the pistons. More specifically work can be defined as a force exerted through a distance. In a mud pump the force is the rod load or the force imposed on the rod system by the action of pressure on a piston. The distance is the stroke of the mud pump. For example, let's take a look at the performance specifications of a typical F-1600 style of pump with a maximum working pressure of 5,000 PSI running at 120 strokes per minute (SPM):

	LINER/PISTON SIZE				
	5"	5-1/2"	6"	6-1/2"	7"
MAX PSI	5,000 PSI	5,000 PSI	4,665 PSI	3,981 PSI	3,423 PSI
GPM @ 120 SPM	367 GPM	444 GPM	529 GPM	620 GPM	720 GPM

A 7" piston has an area of 38.48 square inches. When using a 7" piston, this pump is capable of producing a maximum working pressure of 3,423 PSI as shown in the chart above. The rod load is calculated by multiplying the working pressure times the piston area. In the case of a 7" piston the rod load is 38.48 square inches times 3,428 PSI which is equal to 131,717 lbs. Let's add rod loads to our performance chart:

	LINER/PISTON SIZE				
	5"	5-1/2"	6"	6-1/2"	7"
MAX PSI	5,000 PSI	5,000 PSI	4,665 PSI	3,981 PSI	3,423 PSI
GPM @ 120 SPM	367 GPM	444 GPM	529 GPM	620 GPM	720 GPM
PISTON AREA	19.63 SQ IN	23.76 SQ IN	28.27 SQ IN	33.18 SQ IN	38.48 SQ IN
ROD LOAD	98,150 LBS.	118,800 LBS.	131,880 LBS.	132,090 LBS.	131,717 LBS.

By looking at the chart we are able to come to a few conclusions about this pump. The maximum rod load for this pump is around 132,000 pounds. Using pistons diameters of 6" and up, the maximum working pressure of this pump is determined by the rod load capacity of the power end. Using pistons 5-1/2" and below, the maximum working pressure is determined by the pressure rating of the fluid end. Actually the theoretical crossover point between being rod load limited and fluid end limited is a 5.798" piston diameter.

Let's look at the performance chart of an F-1600 style pump equipped with a Southwest 7,500 PSI upgraded fluid end.

	LINER/PISTON SIZE					
	4-1/2"	5"	5-1/2"	6"	6-1/2"	7"
MAX PSI	7,500 PSI	6,723 PSI	5,556 PSI	4,669 PSI	3,978 PSI	3430 PSI
GPM @ 120 SPM	297 GPM	367 GPM	444 GPM	529 GPM	620 GPM	720 GPM
PISTON AREA	15.90 SQ IN	19.63 SQ IN	23.76 SQ IN	28.27 SQ IN	33.18 SQ IN	38.48 SQ IN
ROD LOAD	119,250 LBS.	131,972 LBS.	132,011 LBS.	131,993 LBS.	131,990 LBS.	131,986 LBS.

Now that we have a fluid end that has a maximum pressure rating of 7,500 PSI, the crossover point at which the working pressure is determined by the fluid end instead of the rod load shifts to the left on the charts. The actual theoretical crossover point occurs with a piston diameter of 4.734 inches.

All the power end is doing is stroking a force (rod load) thru a distance (stroke length of the pump). As you can see by the comparison we just did, the maximum rod load does not increase when switching from a 5,000 PSI fluid end to a 7,500 PSI fluid end. The power end "doesn't know" what fluid end is hanging on the front of it and the horsepower and rod load requirements do not change between 5,000 PSI and 7,500 PSI fluid ends.

Liner Reaction Load

When a mud pump is pumping under pressure, there is a tendency for the liner to push away from the wear plate. This is called the liner reaction load. The liner retainer system is design to retain a liner against the wear plate with enough force to balance the liner reaction load and squeeze the liner gasket sufficiently as to seal between the liner and wear plate. A typical liner reaction load analysis for this pump is shown below:

PISTON SIZE	LINER GASKET O.D.	MAXIMUM PSI	LINER REACTION LOAD
4-1/2"	5-1/2"	7,500 PSI	58,905 LBS.
5"	6"	6,723 PSI	58,083 LBS.
5-1/2"	6-1/2"	5,556 PSI	52,364 LBS.
6"	7"	4,669 PSI	47,671 LBS.
6-1/2"	7-1/2"	3,978 PSI	43,740 LBS.
7"	8"	3,197 PSI	40,409 LBS.

The liner reaction loads in this table are calculated by taking the difference of area of the liner gasket and the area of the piston and multiplying by the maximum working pressure. As you can see, the liner reaction load in this example gets higher with working pressure. Southwest fluid ends feature liner retainers that are fixed directly to the fluid end and therefore do not transfer any of the liner reaction load to the power frame. The number and size of the fasteners used on the liner retainer flange and selected to maintain a large safety factor.

Weight of the Fluid End

There is a small weight difference between a valve over valve fluid end and an L-shaped fluid end. In the example of an F-1600 style pump, the difference is about 1000 pounds per cylinder. This is a small difference comparatively speaking. Since most manufacturers offer an L-shaped fluid end, most power ends are built well enough to handle the small extra weight of an L-shaped fluid end with no adverse effects.

Valve sizes Used in Southwest 7,500 PSI Fluid Ends

Generally speaking Southwest 7,500 PSI fluid ends use smaller valves than equivalent sized 5,000 PSI fluid ends. They also use an API MOD style of valve seats. These seats feature a 1" per foot taper on the outside diameter as opposed to a 2" per foot taper found on the standard API style valve seats. Using a smaller valve and seat makes the valve pots and internal passages of the fluid end slightly smaller and as such increases the life of the fluid end. Since a mud pump is a positive displacement pump, the flow through these passages is not decreased but the flow velocity is increased slightly.

Conclusion

Southwest 7,500 PSI fluid ends are engineered to withstand higher working pressures and have no detrimental effect on the power end. There are a large number of these upgrades working today.

It is important to note that running a mud pump at increased pressures does not come without a price, and that price is reduced volume. Remember that horsepower is the rate at which work is done. If we increase pressure we increase the amount of work that is done because the stroke or distance that we push the fluid is constant. That being said since we are increasing pressure (work) the rate must be lower in order for the horsepower to remain constant. To get increased pressure we use smaller liners so we don't exceed the rod load capacity of the pump. Smaller liners mean smaller volume pumped per stroke. To increase pressure and volume you also need to increase horsepower which means a larger prime mover and a larger power end. If you increase pressure and try to increase volume by stroking the pump faster, (assuming you have enough horsepower in your prime mover) the rate of wear will increase on the power end components, and other damage may occur.

REVISION HISTORY

REV	ECN	DESCRIPTION	CREATED BY:	DATE:	CHECKED BY:	DATE:	APPROVED BY:	DATE:
A		Initial Release	EF	5/18/17	JM	5/18/17	MG	5/18/17