PUMP SPACING ON FIBERGLASS SUCKER RODS

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INTRODUCTION

Production Companies that rely on fiberglass sucker rods to produce oil wells all know how critical pump spacing is to the performance and integrity of the artificial lift system. The idea is that if a well tags bottom (violates minimum load restrictions, gas locks or pounds fluid) with fiberglass sucker rods they will fail. This concept is really no different for steel rods.

As fiberglass rod manufacturers, we recommend not to tag, pump dry, allow gas interference or unload the tubing. This is why it is so important to have the correct pumping spacing off the tag. This will prevent tagging the pump and increase the gas compression ratios to help eliminate gas problems in the pump.
This paper will address the problems and concerns producing companies face while spacing fiberglass sucker rods and a recommended pump spacing chart that will help satisfy pump spacing and gas interference.

Discussion:

It is critical to not tag the pump and also important to consider the gas compression ratio in the pump. Today we need to consider even more the gas compression ratio in the pumps with increasing horizontal wells, pumping above producing zones and increased GOR in wells. These wells seem to produce high volumes of fluid and are prime candidates for a fiberglass rod design.

When spacing out a well with a fiberglass rod design the pump needs to be spaced out high enough to not tag the pump and low enough not to create a problem in the pump with the gas compression ratio.
There is a pump spacing calculation that has been used since the first manufacturer of fiberglass rods realized that spacing would be a problem. Considering at that time there was less than 2-3 years of experience with pumping wells with fiberglass rods a few assumptions were made.

The fiberglass sucker rods will stretch more than steel. The steel rods will stretch about 2 inches per one thousand feet of rods. From these assumptions the following formula was developed.

$$\frac{9\text{” x footage of fiberglass rods}}{1000\text{’}} = \text{f X”}$$

$$\frac{2\text{” x depth of well}}{1000\text{’}} = \text{tX”}$$

fX +tX = total inches of pump spacing off of tag
This calculation has been used with success and maybe a few failures or alterations for over 30 years.
Let’s qualify the formula.

Assumptions:

1. Fiberglass Rods will stretch 9”/1000’ of fiberglass rods installed in well.
2. The combined fiberglass/steel rod string will stretch 2”/1000’ of the depth of the well.

If all wells were the same considering depth over travel of pumping system, fluid gravity, gas production, fluid levels and fluid load on pump this calculation may always have success. There are many other well conditions to consider but for this calculation, the variables of stretch of steel and stretch of fiberglass have the greatest effect on the pump spacing calculations.

The modulus of elasticity for fiberglass will be 7.2 x 10(6)psi for most manufacturers. The modulus of elasticity for steel will be close to 30 x 10(6) (psi). Using these rod specifications, fiberglass rods will stretch 4.17

times more than steel rods. The formula assumes that the fiberglass/steel rod string will stretch 2"/1000' of well depth. This is 4.5 times less than the fiberglass alone. This is a difference of more than 7.5%. This is not a large difference when you calculate pump spacing on fiberglass rods but every inch counts considerably when calculating gas compression ratios in a pump. Therefore, a revised pump spacing formula will be used as discussed later.

Using this formula to calculate pump spacing has always been an accepted practice. However, based on successes, failures and the experience associated with both, operators have developed their own pump spacing criteria considering #1 not to tag and #2 increase the gas compression ratio in the pump.

Operators have developed many options of their own. Here are a few examples.

1. After calculating the spacing from the old formula only 80% of the value is used for pump spacing.
2. Use the old pump spacing calculation, but only use the length of steel rods, not the total depth of well.
3. Use formula to calculate spacing and subtract 12"
4. Use formula to calculate spacing and subtract 10% of value or 90%
5. Space out at only 36" from tag.
6.

All of these calculations are always an option and none are either right or wrong. What is apparent is that operators believe that the pump spacing is important and the current calculation needs some adjustments.

Based on these observations, it seems imperative to develop a more accurate and efficient means of spacing out fiberglass sucker rods. A better understanding of the issues concerning the spacing of a fiberglass sucker rod design is needed.

The spacing of fiberglass rods is very important. Properly spaced fiberglass rods can help reduce failures, increase production and decrease gas interference. As discussed, it may be detrimental to fiberglass rods to pound fluid, gas pound or tag bottom during operation.

These well conditions all create a minimum load violation. This generates a shockwave that is absorbed by the fiberglass rods when it hits the steel/fiberglass rod interface. The results could be immediate failures and reduced cycle life of first expected failure. Likewise, these well conditions also reduce the overall efficiency of the pumping system.

In contrast, the pump needs to be spaced as close to the bottom of the pump as possible to exceed the minimum required compression ratio. This will reduce gas locking, gas pound and increase pump efficiencies. To get a better understanding of the seriousness of this problem, I refer to SPE paper 25418, "Importance of Compression Ratio Calculations in Designing Sucker-Rod Pump Installations." By J.F. McCafferty, Conoco, Inc. The minimum required compression ratio is in direct relation to two main factors for consideration.

First, the gas compression ratio decrease exponentially as the spacing inside the pump increases depending on the type of pump, diameter, stroke length and manufacturer. Minimizing the pump spacing (or wasted space) is critical to help reduce gas interference.

Secondly, as the static reservoir pressure and pump intake pressure decrease the required compression ratio increases exponentially. As the well is pumped down or pumped off, the well has more of a tendency to gas lock or experience gas interference. Therefore, making it more critical to space a well closer to the bottom of a pump in low fluid level wells.

As a result of this discussion, the following conclusions can be made.

1. Fiberglass Rods need to be spaced off of the bottom of the pump and not tag
2. The pump needs to be spaced out off the bottom as close as possible to reduce gas interference
3. Gas interference problems increase as the pump intake pressure decreases

Keeping these parameter in mind, a new philosophy can be determined to space out a well with a fiberglass sucker rod design. It is less critical for a well to have a higher gas compression ratio at higher fluid levels than when the well is pumped off. Based on this philosophy a new concept of spacing a well will use all parameters to determine a new spacing method.

Considering the accepted formula as a standard, a new formula is created.

$$\frac{9\text{" x footage of fiberglass} + 2\text{" x footage of steel}}{1000'}$$

The worst case scenario is a high fluid level well which takes into account all rods in fluid to surface. As the well pumps off the pump intake pressure(PIP) decreases allowing the rods to stretch out more resulting in the need to space out fiberglass higher. As the fluid level decreases, the rods will stretch out more losing over travel, therefore not requiring as much spacing off of the bottom. If a well is spaced out with a high fluid level, the total calculated value from the new formula will be used. If the well is spaced out with very little fluid level or no fluid level, the calculated value will be reduced up to 80%. Therefore, the pump spacing guide (Chart #1) can be used to space out all wells.

The chart is applicable to all depths of wells. The two main considerations to space out every well will be the fluid level above the pump (FLAP) and the percentage of fiberglass rods. As the fluid level drops, the need for a higher pump spacing is reduced based on the percent of FLAP in the well.

For Example: Case #1
8000' pump setting depth
3000' FLAP

4800' fiberglass rods (60%)

Use the 60% line on the chart and the 3000' line on the X axis to the intersect point. Move to the Y axis to indicate pump spacing for this well. The pump spacing will be 33".

The calculated pump spacing based on the old method would be 59.2". This larger pump spacing greatly decreases the gas compression ratio. By reducing the pump spacing to 33" the gas compression ratio is increased significantly, which greatly decreases the possibility of gas interference.

The reason less spacing is needed with a lower fluid level is because the rod stretch has occurred on the rod string because of the low fluid level. As the fluid level is reduced, the spacing needs to be reduced. If the fluid level is high, the rod stretch will increase, resulting in moving the pump plunger down in the pump barrel which warrants the need for higher pump spacing with high fluid levels.

In addition, a critical aspect to pump spacing is how the tag of the pump is achieved. Once all required rods are run in a well and the rods have stacked out, the rods should be picked up no more than the length of the pump. The rods should be lowered very slowly until a tag is felt on the top rod. A mark should be placed on that point on the rod in conjunction with the rod table. The rods should be picked up 4' and then lowered slowly and stopped every 6" until another tag is felt on the top rod. Another mark should be made on the top rod. This procedure should be repeated 3 times to verify the appropriate tag.

After the tag has been determined and proper equipment has been run in the well, the tubing should be loaded with fluid and the tag should be verified again using the same method. After the tubing has been loaded with fluid the rods will have a tendency to float or have increased buoyancy. This could change the tag as much as six inches per 1000' of fluid pumped into the tubing. The tag may change significantly based on the FLAP.

If the FLAP is not available during pump spacing it can be calculated by determining how many barrels of fluid it takes to load the tubing. You can use the formulas below to determine the fluid level.

2 3/8" tubing

$$\frac{\text{BBLS Pumped}}{\text{2.85BBLS}} \text{ x } 1000' \quad - \quad \text{Total Depth of Well} \quad = \quad \text{FLAP}$$

2 7/8" tubing

$$\frac{\text{BBLS Pumped}}{\text{3.6BBLS}} \text{ x } 1000' \quad - \quad \text{Total Depth of Well} \quad = \quad \text{FLAP}$$

These calculations are based on a 1” FG rod string in the 2 3/8” tubimg and 1.25” FG rod string in the 2 7/8” tubing. Knowing the percentage of fiberglass sucker rods in the well and the FLAP, the pump spacing chart can now be used to determine the pump spacing for the pump.

The parameters and actions needed to use the new pumping spacing chart are as follows:

1. Fluid level above pump
2. Percentage of fiberglass rods in well
3. Fill tubing with fluid
4. Tag well as outlined
5.

In conclusion, this pumping spacing chart will help (1) reduce gas interference in wells with fiberglass rods; (2) optimize pump efficiencies; and (3) reduce failures. The new pump spacing chart takes into consideration all aspects and experience gained over the past 35 years. Considering the gas problems experienced in producing wells today and old pump spacing techniques, a new idea for pump spacing is generated to optimize pumping with a fiberglass rod design.

Pump Spacing

(Based on Fluid Level Over Pump per % of Fiberglass)