

# Plunger Lift: Applications, Operations and Its Effect on Measurement Systems



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## Abstract

The growing popularity of plunger-lift as a serious production technique is testimony to the effectiveness of this often misunderstood process. Once rarely considered, plunger lift is now being used by prudent operators all over the world. The need for continued education and information for production operators continues to grow. Even though the basic applications remain the same, the parameters are changing. Thousands of wells that would never have been considered as candidates previously can now be operated effectively and efficiently.

Many of the problems associated with plunger-lift have been solved. Controls have become state-of-the-art. Electronic supervision, automation and optimization have created options that were not possible just a few years ago. Gas measurement, management and supervision gives operators hands-free operation with excellent accuracy, reliability and flexibility.

This paper will describe the applications, and operations of today's plunger-lift systems. It will also address the effects on gas measurement and the options available through new technology.

## Introduction

Plunger-lift was once considered a profanity by many. It was seldom used, poorly designed, and troublesome to operate. All this was true even if it has been installed on a good candidate (and it often wasn't)! Still, in some places today, it is almost necessary to defend oneself if you mention plunger-lift. More than one operator has sworn that if they ever got that (expletive deleted) thing out of the well they would never use another one.

Plunger-lift today is a whole different story. Most of today's systems are quite different from those of yesterday. Plungers are more efficient, controllers are more sophisticated, operators are more knowledgeable, and service technicians have a bag of tricks to solve the operational problems. There is also much better understanding of the proper applications, and of the limitations.

## Applications

There are four basic applications for plunger-lift, however, the possibilities within these four have expanded. They are:

1. Gas Wells With Liquid Loading Problems
2. High Ratio Oil Wells
3. Flowing and Gas Lift With Paraffin Problems
4. Intermittent Gas-Lift Wells

## 1. Gas Wells With Liquid Loading Problems

The majority of plunger-lift wells fall within this category. Most gas wells tend to experience liquid loading at some time in the life of the well, and plunger-lift can be used on the majority of these wells. It is an inexpensive, reliable method for keeping these wells on-line and extending their economic limits. While there are other stop-gap measures that can be taken, only plunger-lift offers an efficient, permanent, cost-effective solution.

Plunger-lift addresses liquid loading by using a piston (plunger) that travels the entire length of the tubing. Each trip the plunger makes, from the bottom of the well to the surface, it brings whatever liquid that has accumulated in the tubing, to the surface. This effectively reduces the average flowing bottom hole pressure of the well, and maintains higher productivity from the well.

## 2. High Ratio Oil Wells

Years ago, it was a common practice to install a rod pump on most wells that quit flowing, or had liquid loading problems. The equipment was understood, readily available, and universally accepted by the industry. Even though stroke inefficiency on it, or gas locking was often the result, many operators continued down this path. It wasn't until the mid 80's, when economics became a greater concern, that plunger-lift was given a serious look for this application. Dollars became tight, and prudent operators began looking for alternatives.

Today, plunger-lift is installed in almost as many oil wells as gas wells. The equipment is more efficient, so wells with lower GLR's are better candidates than before. The control systems offer greater flexibility, and are easy to operate. It remains the least expensive method of artificial lift.

Its operation is very similar to gas well operation. The major difference is in determination of the cycles. The plunger itself is often different on a high ratio gas well. This is due



to the need for better seals on the plunger to maximize the efficiency of the lift gas.

### 3. Flowing and Gas Lift With Paraffin Problems

This is the simplest of all plunger applications. It doesn't require any serious calculations, or studies to determine if a well is a candidate. The goal is to keep the tubing free of paraffin, and a plunger can do that easily. By virtue of having a piston traveling inside the tubing several times each day, paraffin accumulation is not possible. The wiping action of the plunger doesn't allow paraffin to form.

If the well has no obstructions inside the tubing, such as safety valves, storm chokes or undersized nipples, a plunger can be used. The key is to start with the tubing clean and never permit the paraffin to form. It may take as many as six to eight cycles per day to keep the tubing clean, but can be easily accomplished with a plunger-lift system. Each time the plunger travels, it wipes the inside walls of the tubing.

### 4. Intermittent Gas-Lift Wells

Intermittent gas-lift wells have inefficiency built-in. Because of the dynamics of slug lift, there is always a portion of the starting slug that will fall back to the bottom. This fall-back is created because the gas is traveling faster than the fluid, and there is a frictional drag on the inside walls of the tubing. As the slug moves toward the surface, gas begins to break through the fluid column. Most of the liquid that is passed, falls back to the bottom. The greater the depth of the well, the greater the volume fall-back. The result of this fall-back is an increase in the average flowing bottom hole pressure. The greater the percentage of fallback, the greater the negative effect on the flowing bottom hole pressure.

Intermittent gas lift wells can be ideal plunger-lift candidates. The plunger serves as a mechanical interface between the liquid column and the injected gas, so that fall-back is completely eliminated. By eliminating fall-back, production is increased. Typical plunger-lift/gas-lift wells realize both an increase in liquid production, and a decrease in injected lift gas.

Determination as to a well's suitability for plunger-lift is quite simple. Production data, well depth, gas pressure/volume and other well data have already been taken into consideration to design the gas lift system. This ensures that there is sufficient gas to operate the plunger-lift system. The biggest single limitation to using plunger-lift in this type well is the timing of the injection cycles for the plunger to reach the bottom. If there is not enough time, the plunger should not be used.

### Operation

All plunger-lift operations are very similar. In most cases, the equipment can actually be transferred from one type well to another with little or no changes. The typical system includes a lubricator and a catcher at the surface. These are mounted on the well head, above the master valve. They provide for an upper limit and serve as a shock absorber for the plunger as it arrives at the surface. The catcher is there to manually catch the plunger to remove it for inspection or replacement. Downhole, there is a bumper spring and stop. These are usually installed by wireline, and are there to serve as a shock absorber for the plunger as it arrives at the surface. The catcher is there to manually catch the plunger to remove it for inspection or replacement. Downhole, there is a bumper spring and stop. These are usually installed by wireline, and are there to serve as a shock absorber and limit to the plunger's fall. The plunger travels freely between the spring in the Lubricator and the spring downhole. The control mechanism is a motor valve and electric controller mounted on the flow line. The valve starts and stops well flow, which controls plunger travel. Many controllers today require some indication as to when the plunger reaches the surface. A sensor is often mounted at or near the catcher to provide this signal to the controller.

### Gas Wells And High Ratio Oil Wells

Most successful plunger-lift operations are in wells with no packer. By having the casing annulus available this provides an area for gas storage. When the well is shut-in, the plunger starts to fall, and the pressure starts to increase in the annulus. The well remains shut in for enough time to allow the plunger to reach the bottom, and to build up enough pressure to lift the plunger to the surface. When this time has passed (pressure has increased), the motor valve on the flow line is opened.

When the motor valve opens, the head gas (gas in the tubing above the fluid) is produced first. As this gas is produced, a pressure differential is created across the plunger and the liquid slug above. With sufficient differential, the plunger starts moving toward the surface, with the liquid above it. As the plunger moves toward the surface, the gas from the casing moves from the casing into the tubing, pushing or lifting the plunger to the surface.

In the case of a high ratio oil well, when the plunger reaches the surface, the arrival sensor sends a signal to the controller that the plunger has arrived. This causes the well to be shut in, and the cycle repeated.



A gas well generally differs in that when the plunger reaches the surface, the well is not shut in immediately, but continues to flow. This flow can continue for a few minutes up to a few hours, depending on the strength of the well. When the well is shut in, the cycle is repeated.

### Paraffin Control

The operation of a plunger-lift system on a well for paraffin control only is usually controlled using time. The well is left open (flowing) for several hours at a time, and only shut in for a few minutes every four to eight hours. The shut in time is only long enough to allow the plunger to fall to the bumper spring. In this type well the bumper spring is installed slightly below the lowest level of paraffin rather than on bottom.

It is important the well be cleaned of all paraffin before attempting to use a plunger-lift system. A plunger cannot travel if there is already a paraffin buildup. Once the well is cleaned, it is then possible to cycle the plunger so that paraffin does not accumulate. The plunger must travel from the surface to the lowest level of paraffin to ensure that the tubing is clean.

Wells that experience problems with scale and hydrates can also utilize plunger-lift. The operation is essentially the same as with paraffin. The well must be clean to start the operation, then the plunger can maintain the tubing clean.

### Intermittent Gas Lift

Ideally, the operation of an intermittent gas lift well will not change with the installation of a plunger-lift system, it will merely operate more efficiently. If the gas lift system has been optimized, and is operating correctly and efficiently, it will already have the best cycles for the well with plunger-lift. Plunger-lift is only an aid for the gas lift system.

What will change is the efficiency of the gas lift operation and the production of the well. Intermittent gas lift wells have a percentage (5%/barrel/1000ft of depth) of their starting slug that falls back to the bottom. A plunger serves as a mechanical interface between the liquid and the lift gas. The major consideration in this system is that the plunger be back on bottom before the next cycle of injection gas.

Each time the injection gas lift valve opens, gas moves from the casing into the tubing. This gas enters the tubing directly below the plunger, and starts pushing it toward the surface. The liquid that is above the plunger is lifted, along with the plunger. Because of the seal characteristics of a plunger, liquid cannot fall back to the bottom. This means better liquid production, and less injection gas.

### Gas Measurement Problems / Considerations

Plunger-lift is an intermittent operation. A valve on the flow line is opened and closed during each cycle (this is not the case with intermittent gas lift). During the time this valve is closed, pressure builds in the tubing and in the casing. When it is reopened, there is a surge of gas that is produced. This surge can present problems to the typical paper chart and pen measurement systems. This surge will often be great enough that measurement will be off the chart; thus gas is given away to the buyer. It is possible to use a larger orifice plate to keep the flow on the chart, but this can create other measurement problems on the low end of the flow cycle.

The “typical” circular chart measurement system remains the most widely used and accepted measurement. Its measurement accuracy is quite acceptable on flowing wells, especially those with relatively consistent flow. As wells become more marginal in their flow characteristics, traditional measurement techniques become less acceptable. This is especially true with the intermittent operation of plunger-lift.

The initial surge of gas is very difficult to measure. This surge often causes the pen to go off the chart. As the liquid slug approaches the surface, the differential drops quite low. Then when the plunger reaches the surface, the differential is high again. All these variations make it difficult to choose an orifice plate sized correctly to get good measurement.

One solution prescribed to by many operators is to use a choke. By choking back the initial surge, the measurement is better, and easier to read. It essentially smooths out the cycles. It also creates serious problems for the plunger-lift system. For a plunger to travel efficiently, it requires a pressure differential across the plunger and the liquid slug above. If the head gas is bled off too slowly, as is the case with a choke, the plunger cannot travel efficiently. In many cases it may not travel at all. Also, the size choke most efficient to handle the surge will be too small for good flow during the rest of the cycle; therefore, chokes are difficult to utilize efficiently in this application.

Many times, the measurement problem will be self-correcting. After a well has been on plunger-lift for a short time, the cycles tend to smooth out. Often they smooth out enough that measurement becomes more acceptable. The surge is not as strong, and the drop in differential when the plunger is traveling up the hole is less. Therefore, choking or throttling is not necessary.



Throttling is a solution that is much more acceptable than choking. With throttling, the production motor valve is not allowed to open fully if the pressure/differential is too high. The valve opens slowly, and only a percentage of its full opening range. This allows a smaller, controlled surge. As the pressure tends to drop after the surge, the valve opens fully to get the best flow characteristics. This method is a much more acceptable solution. A number of valve companies build reliable devices that will throttle a motor valve. Other methods, such as larger orifice plates, surge bottles/chambers and venting head gas, have their place. Many times it is necessary to combine two or more types of flow control.

Electronic gas measurement offers one of the better solutions. Many of the new systems offer more than the typical 100 inches of measurement. They also take the human element out of chart integration (which can prove quite difficult on an intermittent chart). By providing actual second to second flow data, rather than a line which must be integrated, high flow, low flow, and surges are measured more accurately. It also ends the advantage gas buyers tend to have over gas sellers. It puts accurate, reliable data in the hands of buyers and sellers alike. This data can be transmitted via telemetry, so up to date data can be received quickly.

For as long as the circular paper chart method of measurement is used, intermittent flow will remain difficult

to integrate. This will remain true for all types of intermittent wells. Today we see the industry moving toward more and more electronic gas measurement, both with and without telemetry. From a plunger-lift standpoint, this is an important move because there is more and more plunger-lift in operation each year. Electronic flow measurement will solve the measurement problems.

### Summary

Plunger-lift remains the least expensive method for producing wells with marginal flow characteristics. It is not a cure-all, and will not work on every well. Even though the technology and experience have advanced dramatically, it is still necessary to look at each well individually to determine if it is a suitable candidate. If so, a system frequently will pay itself out in 30 to 45 days or less.

Many of the problems associated with plunger-lift are now a thing of the past. There are operational situations, which should be considered before installing equipment. Gas measurement problems are easily solved with a variety of controls and with different types of measurement. This is especially true when using Electronic Gas Measurement. The reputable plunger-lift companies can easily provide you with data on the many different options available, and will be able to help determine, if needed, a well is a candidate.

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## BIOGRAPHY

### Stanley J. Morrow, Jr.

29 years experience in dealing with oil and gas production. This includes both gas-lift and plunger-lift. Special emphasis during the past 19 years has been to gas production and to wells with marginal flow characteristics. A member of the Society of Petroleum Engineers, and both an author and co-author of numerous technical papers dealing with plunger-lift. For the past 20 years has worked for Ferguson Beauregard/Logic Controls. Experienced in all aspects of field operations and service, equipment design and function, well applications, engineering and manufacturing. Responsibilities include both domestic and international operations, and much time is devoted to educational efforts including schools, courses, and seminars conducted in many countries. Current position is President