LRP® Linear Rod Pump Excels in Urban Settings

Compact and minimally obtrusive, Unico's LRP® Linear Rod Pump easily goes where traditional systems would be unacceptable or even dangerous, such as urban settings. This system is tapping underground opportunities within the tight confines of a parking lot island. The system takes up a fraction of the space of a traditional system and is comparatively quiet. Since the only exposed moving part is the polished rod, the system has none of the dangerous pinch points associated with a walking-beam mechanism. A simple screen that can be added around the mounting base completely eliminates access to any moving parts without requiring unsightly fencing or enclosures. For more information about the LRP® Linear Rod Pump, please contact us.

Making an Intelligent Trade-Off Between Pumping Unit Stroke Length and Stroke Rate

by Christopher Schmidt oil and gas division sales manager
Unico’s LRP® Linear Rod Pump is a unique artificial lift system that uses direct-drive mechanics and servo capabilities to provide an unprecedented degree of control over the rod string. Linear actuators have significant advantages over walking-beam type pumping units, including relatively small size and weight, ease of transportation and installation, inherent safety and aesthetics, low noise, enhanced production, and dynamic load management.

While both types of systems provide reciprocating motion, aspects of the linear rod pump differ in application and behavior from traditional pumps in ways that may seem unfamiliar or even counterintuitive at times.

For example, we frequently encounter resistance on the part of customers to running these units at high cycle rates. When sizing linear rod pump systems, we attempt to minimize pumping unit size and cost by selecting units with shorter stroke lengths and running them at a faster stroke rate. Many are uncomfortable with the trade-off, as they associate higher pumping speeds with rod float problems. This apprehension often stems from a misunderstanding of the issue of rod fall and, in particular, of how the linear rod pump operates.

Rod fall refers to the downward travel of the rod string during the pump’s downstroke. Normally, the load on the rod string is sufficient to maintain tension as the walking beam lowers. However, viscous and other frictional and buoyant forces retard the free fall of the rod. Problems arise when the pumping unit travels faster than the rod is capable of falling. This causes the rod to “float” and buckle, leading to bridle separation and undesirable wear of the tubing and rod. There is a maximum rate at which the rod can fall for a given well that ultimately constrains the operation of the pump. While frequently thought of as a terminal velocity, this limit is more accurately a limitation on the acceleration of the rod.

Conventional wisdom says that to avoid rod float, a longer stroke length should be used. There is some truth to this with traditional pumping units. Acceleration on these systems is a function, due to their four-bar linkage, of the square of the stroking rate. A longer length run at a lower strokes per minute does not require the pumping unit to accelerate as hard, which helps keep the rod from hitting the rod fall constraint.

Oil industry charts show that there is a range of “safe” stroke rate/stroke
length combinations that will not cause the rod to float. The charts below illustrate this for conventional and phased-crank (Mark II) geometries. They assume a maximum rod fall velocity of 1,400 inches per minute and take into account the changes in acceleration of the rod with stroke length. In practice, rod fall varies from well to well. As can be seen, a conventional lift with a 64-inch stroke can be run at a maximum 23 spm while a 32-inch unit, having half the stroke, can safely be run at 33 spm without exceeding the rod fall limit (though this may be impractical for other reasons).

Industry charts illustrate the relationship between stroke length and maximum stroke rate, as permitted by rod fall, for conventional and phased-crank pumping units.

With a linear rod pump, it's an entirely different story. While the motion profile of a walking beam system is forever fixed by its geometry, the linear rod pump has complete control over the speed and acceleration of the rod string throughout the stroke. Upstroke and downstroke speeds can be varied independently, and the shape of the motion profile can be controlled through programmable acceleration and deceleration rates.

Since its acceleration and deceleration times are fixed, not dependent upon stroke rate, the linear rod pump behaves consistently regardless of stroke length. The propensity for the rod to float is no different for long or short lengths.

Because it can change direction quickly, the linear rod pump can also have
lower peak rod speeds than a walking beam pump, even at higher stroking rates. Whereas a walking beam has a cycloidal rod velocity profile, the profile of the linear rod pump is trapezoidal in shape with controlled acceleration through the endpoints or corners. The faster the acceleration through the corners, the less speed is required down the straightaway to cover the same rod stroke. This lowers the peak rod velocity and flattens the top of the profile.

Class I geometry pump versus a linear rod pump with acceleration times of 75% (top) and 25% (bottom) of the pump cycle time. By accelerating and decelerating faster, the linear rod pump can cover the same stroking distance in less time, lowering the peak velocity and flattening the motion profile. This allows the stroking rate to be pushed higher than with traditional systems.

This capability of the linear rod pump to cover greater distance for any given peak speed can be used to increase the pump stroking rate and production without exceeding rod fall limits. The additional headroom by manipulating the motion profile allows the stroking rate to be pushed about 40% higher than with traditional systems. On shallow wells, the limits can be stretched even further by increasing the upstroke speed relative to the downstroke speed. A comparison chart of linear and traditional systems is shown in the accompanying Online Stroke Rate Calculator article below.

The trade-off between stroke length and stroking rate can also be illustrated using a program developed to analyze the linear rod pump performance. An analysis was run with a 10 hp linear rod pump on a well with a depth of 1,000 feet as the stroke length was varied between 32 and 64 inches. All other well parameters and the model of the linear rod pump were kept the same.

**LRP® Stroke Length/Rate Comparison**
While both units produce nearly the same fluid flow, the unit with the 64-inch stroke runs at a maximum pump speed of 6.3 spm, while the 32-inch unit operates at twice the rate or 12.6 spm. In other words, with a linear rod pump, the stroke rate and stroke length are proportionally related. One can make direct trade-offs between stroke length and stroking rate as long as rod stretch is not significant, as is the case with shallower wells. In any event, both these stroking rates are well within the maximum stroking rate limits dictated by rod fall.

On deeper wells, rod stretch can be an issue. With a very long rod string, the rod stretches and relaxes with every stroke, reducing the effectiveness of the stroke downhole. These types of wells benefit from a longer surface stroke to create adequate downhole pump movement.

The issue of rod fall velocity is really a moot point with LRP® systems. In addition to its inherent ability to minimize rod float issues through acceleration control, the linear rod pump can explicitly avoid the problem by monitoring and controlling rod load dynamically. If the rod load on the downstroke is too low, the pump automatically adapts by slowing to maintain sufficient tension and prevent bridle separation. This robust closed-loop approach works regardless of rod fall velocity, fluid viscosity, friction, and other factors.

So what is the advantage of using shorter strokes? The primary benefit is cost savings. For the example above, using the 32-inch rather than the 64-inch actuator saves 24% on the initial capital investment. The smaller unit is also easier to install, less costly to maintain, and even less obtrusive for well sites where appearance is a concern. These advantages are adequate justification for becoming comfortable with the stroke length/stroke rate trade-off.

For more information on linear rod pump systems or the stroke length/stroke rate trade-off, please contact us.
Unico has developed an online *Stroke Rate Calculator* that analyzes the stroke length versus stroke rate trade-off for LRP® Linear Rod Pump and traditional sucker-rod pumping systems. The calculator can be found at


The calculator determines the maximum practical stroking speed in strokes per minute for a given stroke length based on the maximum rod fall velocity and, for LRP® systems, the acceleration/deceleration time. The calculator combines the industry rod fall velocity standard for conventional, air-balanced, and phased-crank (Mark II) pumping units with the LRP® limits.

For LRP® units, two different results are calculated. Since the industry charts allow increased rod fall velocities as the stroke length increases, the first calculation is based on the conventional pumping unit fall velocity as a function of stroke length. The second calculation uses a selectable but fixed fall velocity limit.

The chart at right graphs the results of the calculator using a maximum rod fall velocity of 740 feet/minute and LRP® pumping unit acceleration time of 0.25 seconds.

We hope you find this calculator a useful tool. If you have comments or questions, please contact us.
In Future Issues...

Look for the following articles in upcoming issues of *Oil & Gas Automation Solutions*:

- Field tests of methods to eliminate rod pump gas locking and interference
- Reducing power consumption and improving power factor of beam pumps
- Using a torque economizer mode to improve efficiency and reduce gearbox stress
- Control options to ride through power disturbances
- Loss of methane gas production due to overpumping CBM wells
- Use of low-profile CRP® and LRP® pumping units with traveling irrigation systems
- Air counterbalance increases LRP® linear rod pump lift capacity