Classification and Application of Sucker Rod Pumps

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IDENTIFYING SUBSURFACE PUMPS

The API undertook a tremendous job of classifying and identifying the many subsurface pumps available to the industry. As a result of their efforts we now have a set of symbols for the purpose of pump identification.

All pumps not covered by this set of symbols are classed as Types of pumps. They, too, are made up of as many API parts as possible to keep down the expense of handling so many different parts by both manufacturer and operator.

Lifting costs can be greatly reduced by proper selection of your subsurface pump. This selection is influenced by the well condition as most wells offer a wide and varied assortment of problems which can not be solved by merely installing a pump. However, after you have carefully analysed the well, I believe you will find a suitable pump available for almost every well condition.

The basic units of a subsurface pump consists of 4 parts. The Barrel, the Plunger, the Travelling Valve, and the Standing Valve. The Barrel is a tube that furnishes one half of the pump's fluid seal. The Plunger works in the tube to furnish the other half of the seal and to lift the oil. The Standing Valve, at the bottom of the pump, opens on the up stroke to let oil in to the pump from the well bore, and closes on the down stroke to hold the oil in the pump. The Travelling Valve, at the top of the pump, opens on the down stroke to let the oil above the standing valve pass through the plunger, and closes on the up stroke to send the oil upward through the tubing.

Considerable research is being done in labs of pump manufacturers. The results are very gratifying in that the industry has been presented with metals to resist corrosion, abrasion, high temperatures, stress, and fatigue. Now that we have these tools to work with, our lifting costs can be reduced considerably.

BALLS AND SEATS

The heart of any pump is the valve system and a proper selection of balls and seats can make your operation more efficient. Wells that operate with sand and abrasion precipitating out into the well bore can be a problem if the wrong type balls and seats are used. A number of wells operating in shallow and medium depth fields where there is no magnetism or corrosion present can often use a hard stainless steel ball with seat that is very hard and is also low in price; however, if either magnetism or corrosion is present a good stellite alloy ball and seat would be resistant to magnetism and corrosion and it would stand up very well under the sand condition. Cost would still be in line. If tests prove, however, that the sand is sharp and coarse and that your pump repairs are high due to ball and seats cutting out, you have only one alternative; that is to use a tungsten carbide ball and seat which will cost considerably more than the stellite. Proper selection will cut down your costs of lifting oil.

Analyse your well and make the proper tests and see how much you can cut down your lifting costs by using the proper ball and seat for that well.

PLUNGERS

A wide selection of plungers are available for your pumps. Their construction has been influenced by the service requirements imposed on the pump by various fluids found in wells. Careful consideration must be given the plunger requirements because the service it will give is influenced by your analysis of your well condition.

The general considerations influencing plunger life are the height of fluid lift, the abrasive characteristics of the well fluid, bottom hole temperature, water content of fluid, and fluid viscosity at the bottom of the hole and its temperature. The height of fluid lift determines the working pressure at the pump and the fluid load imposed on the plunger. The abrasive characteristics of the fluid have a definite influence on plunger selection, because the mechanical characteristics of the sealing element influence its resistance to abrasion. The bottom hole temperature may influence plunger choice, because high temperature will produce undesirable changes in mechanical makeup of rubber sealing elements. The water content of fluid partially controls its value as a lubricant and influences plunger choice and fit. The viscosity of the fluid is an important consideration, because it determines the rate of fluid slippage through small openings.

BARRELS

Barrels are available in two types and made out of many materials to combat the well conditions.

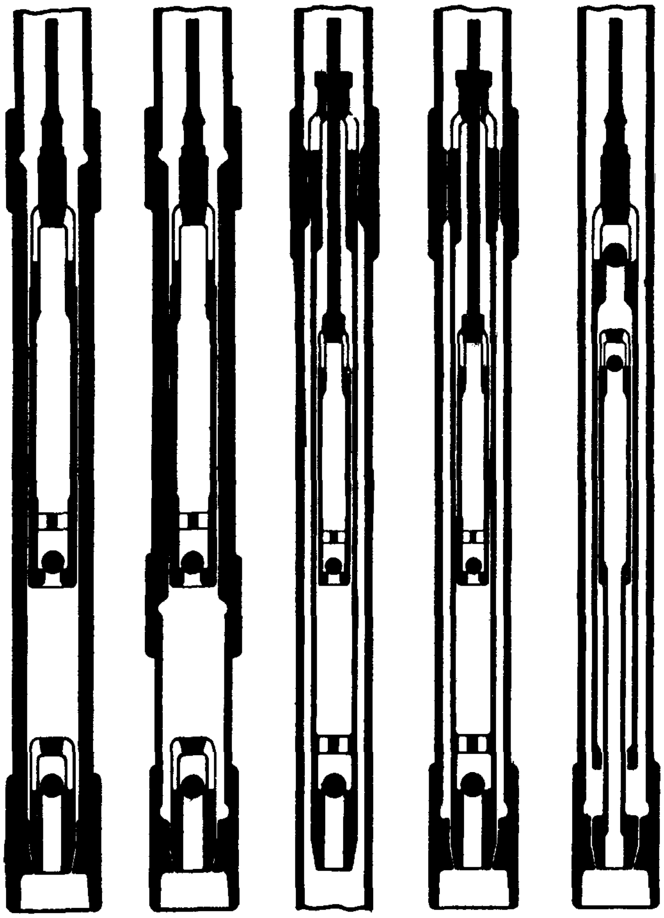
Full Barrel: The full barrel is a one piece unit in which the inner surface is finished to form an accurate sealing surface. This full barrel is available in tubing pumps and rod pumps.

Liner Barrel: The liner barrel is a composite unit consisting of a jacket, a given number of liners, and 2 collars which hold liners in place within the jacket. These, too, are available in many metals and combat corrosion and abrasion.

We have briefly discussed the basic parts of a pump. The following chart illustrates the API and Special Pumps available to the industry.

TUBING PUMPS

The two basic classifications of sucker rod pumps are the tubing type and the rod type. The tubing type is run on the tubing and the rod type is run on the rods through the rubing. Either can have a full barrel, section liners, or a full liner. The rod pump can be either a stationary barrel type or a travelling barrel type. The travelling barrel rod pump can have a bottom holddown only but the stationary barrel can be seated either with top holddown or bottom holddown. The tubing pump can be run with or without an extension nipple but it must have a shoe in which to seat the standing valve assembly. These tubing pumps are available with all types of plungers. Their plungers, travelling valves and standing valves can be removed from and run into the well on the sucker



(1) TW TL | (2) TWE TLE | (3) RWA RLA | (4) RWB RLB | (5) RWT RLT

DIAGRAMS ILLUSTRATING API PUMP CLASSIFICATION

Type of Pumps	Abbreviations: Full Barrel	Abbreviations: Liner Barrel
(1) Tubing Type, with Shoe..............	TW	TL
(2) Tubing Type, with Extension Shoe and Nipple............................	TWE	TLE
(3) Rod Type, Stationary Barrel, with Top Hold-Down....................	RWA	RLA
(4) Rod Type, Stationary Barrel, with Bottom Hold-Down..............	RWB	RLB
(5) Rod Type, Traveling Barrel........	RWT	RLT

Note: See explanatory diagrams numbered in accordance with above.

1st letter
- **T=Tubing type; non-inserted, run on tubing.**
- **R=Rod or "inserted" type; run on the rods, through tubing.**

2nd letter
- **W=Full barrel; supersedes "cold-drawn working barrel", also "cast-iron" type.**
- **L=Liner Barrel; includes sectional and full liners.**

3rd letter
- **E=Tubing pump with extension nipple and shoe.**
- **A=Stationary barrel rod pump with top hold-down.**
- **B=Stationary barrel rod pump with bottom hold-down.**
- **T=Traveling barrel rod pump.**

From API Standard No. 11-A

rods. This type pump is available in a large selection of sizes amd materials for your well condition.

Tubing pumps with shoe type (TW or TL) are best applied to wells having little or no sand, as the plunger can not stroke out of the bottom of the barrel and clean itself. It is a high volume type pump, to be used in wells with normal operating conditions.

Tubing pumps with extension nipple and shoe type (TWE or TLE) are best applied to wells making sand, scale, gyp and paraffin fall out. The plunger and barrel length should be carefully chosen to allow the plunger to stroke out of each end of the barrel. This prevents scale build up and cleans the plunger and barrel on each stroke. The removal of the plunger and standing valve in wells making scale is facilitated when it is necessary to repair rod breaks or pull the well. This is also the most economical of the two tubing pumps as the barrel tube is shorter and when replaced the cost is less.

Tubing pumps operate better than any other type in crooked holes. The plunger is more likely to go down the tubing and pass a kink or dog leg better than a longer pump would.

INSERT PUMPS

Top Hold Down Pumps Type RWA And RLA

This type of pump is recommended for wells where sand is a problem and the capacity of this pump is needed. The pump is seated in the seating nipple at the top of the pump, thereby permitting it to be suspended. This is an advantage in a sandy well as the sand can not settle between the annulus between the pump barrel and the tubing, which would prevent the pulling of the pump when needed. The flow of fluid is then coming out of the top of the pump directly at the seating nipple. If the proper size of pump is used, the fluid velocity will carry the sand out of the well. Another advantage is the ability to submerge this pump in a low fluid level well, allowing it to fill better, and providing a better operating pump in gassy well due to the submergence of the valves.

Top holddown pumps are limited to setting depths due to the pressure differential between the inside and outside of the barrel tube. This differential may expand or split the barrel. In cases of deep wells the weight of the column of fluid can be excessive and impose a greater load than the barrel tube is designed for, causing it to drop off when fatigued. This can be overcome by installing a shoe and seating nipple in a proper length jacket when the tubing is run in the well: the design of the pump will be to seat at the top and bottom simultaneously. This practice is popular in deep wells where foreign materials precipitate out of the fluid and settle down around the pump.

Bottom Hold Down Pumps Type RWB And RLB

This type pump is best suited to the production of clean and gassy oils. Like its brother, the top hold down pump, the suction system offers low resistance to the fluid flow, and it will operate efficiently in gassy wells when properly spaced. It is not limited to setting depth as the pressure is equalized inside and outside the barrel tube.

When seated and properly spaced there is a minimum of unswept area between the standing valve and the travelling valve at the bottom of the down stroke.

A pump becomes gas locked when free gas gets into the unswept area between the valves where it will expand and contract with each stroke, thus interfering with valve operation.

When a pump is partially gas locked its efficiency is very poor, as most of the stroke is spent in compressing the free gas in the pump. When a pump is completely gas locked no fluid can be pumped, due to insufficient compression of the gas inside the pump to open the travelling valve.

Traveling Barrel Type RWT And RLT

This is the most versatile of all pumps in the insert type class. It will operate in normal wells, sandy wells, and corrosive wells with better results than any other single style or type of pump made today.

The travelling valve system acts as a sand check and prevents sand from settling on top of the plunger when the well is shut down. The continuous surging of fluid in and out of the lower end of the barrel sets up a turbulence and prevents sand from settling around the pump and sticking in the tubing.

This agitation also prevents the corrosive fluid from lying dormant around the annulus between the tubing and the barrel and thereby becoming more intense as it is moved right up the tubing along with the sand and fluid from the well bore.

Both of the valves operate in open cages and this provides less restriction when moving or pumping heavy fluids. The pressure is equalized as it is in the stationary barrel bottom holddown type pump.

In wells that make large volumes of sand it will be well to remember that the sand can settle gradually in the annulus between the tubing and the barrel. When sufficient sand has settled it will prevent the pump from making a full stroke on the down movement. This pump will gas lock easier than the stationary barrel type pump due to the standing valve being smaller than the travelling valve.

The entrance or standing valve should be the largest to secure maximum in gas lock protection. A smaller entrance opening will make gas come out of solution faster than it would in a larger opening. The pressure drop is greater across a small valve than it is over a large valve. In crooked or slant holes the travelling barrel pump will operate with more friction than a stationary barrel type pump and thereby place rods in compression. A loss of stroke is the result, plus a worn barrel tube and tubing. The high position of the valve system does not lend itself to a good application for a low fluid level well.

The Three Tube Or Multiple Tube Pump

This insert type pump is designated for all around efficient pumping. It is particularly adapted to handling especially abrasive, dirty, or sandy production, and for wells where the bottom hole temperatures are unusually high, causing unequal coefficients of expansion in close fitting metal pumps. The "fluid seal" principle in the design offers a number of operating advantages not available in conventional rod pumps.

Because of the loose fitting, free falling plunger and the comparatively small bore and consequently higher fluid velocity, the three tube pump is extremely efficient in handling floating sand. The small bore diameter also subjects the rods to less stress and elastic elongation in deep well pumping and the free dropping plunger can be operated at greater strokes per minute rate. Plunger friction and abnormal wear of working parts are considerably lessened, which assures a minimum of down time and repairs. The fluid discharge is at the top of this pump through an open type cage. The barrel moving up and down on each stroke again prevents corrosive fluids from becoming more intense at the seating nipple. At the same time it keeps the fall back sand and trash flowing with the fluid being moved.

Because they depend on the length of the tubes and their arrangement for the seal and the prevention of excessive slippage, multiple tube pumps are longer than conventional types. The following table shows the proper length for different lengths.

DEPTH OF WELL	LENGTH OF PUMP
Less than 2000'	12'
2000' to 3500'	15'
3500' to 5000'	18'
5000' and deeper	25'

These pumps are made in the following sizes:

2 inch Tubing - 1-1/4 inch Bore
2-1/2 inch Tubing - 1-3/4 inch Bore
3 inch Tubing - 2-1/2 inch Bore

These pumps are available with off and on attachments. These attachments enable operators to pull the rods and bring out the outer and inner barrel of the pump in the event of a power failure or rod break should sand or trash settling down around the pump make it impossible to pull without a stripping job. The above pump can also be made to operate in a seating nipple attached to a packer and set as a large volume pump for handling water sometimes used for injection wells, or any application where this type is needed in big bore capacity. Multiple tube pumps should not be operated under slow stroke hydraulic units or at speeds less than 10 strokes per minute.

Pumps must be completely submerged; therefore, they are not applicable to low fluid level wells.

TEXAS STRIPPER

This is a special pump for stripper wells. It is designed to prevent sanding-up of the pump and to reduce pump failures that are caused by sand and well trash that settle from the fluid column through the discharge ports and into the pump bore during the shut-down periods. The discharge ports of the Texas stripper rod pump are completely protected from settling sand and well trash by a long outer jacket tube connected to the rod coupling to reciprocate with the plunger. The discharge ports, because they are enclosed by the jacket tube, are not directly exposed to the upper fluid column or to any settling action that would sand in the pump. Fluid, as it is discharged through the ports, must travel downward in the annulus between the outer jacket and the barrel tube.

Sand and well trash are agitated upward and away from the pump as the fluid passes into the production column near the bottom of the pump. Even when the well pumps off, the agitation continues. The well can be stopped on up or down stroke and the agitation of fluid at the seating nipple is immediate when well is started up. This pump is a stripper pump and is available in 1-1/16 inch bore for 2-inch tubing, and in 1-1/16-inch, 1-1/4-inch and 1-1/2-inch for 2-1/2-inch tubing. It is an excellent pump for a water flood where the primary operation can use this bore of pump and through the secondary operation when sand and well trash often comes in with low volumes of fluid before the flood reaches high volume capacity. It can be applied in low fluid level wells as it can be close fitted. It has the advantages of a top holddown pump in that the discharge is at the seating nipple and is difficult to stick.

The agitation prevents corrosion from becoming more intense at the seating nipple. The large standing valve and small travelling valve make it resist gas lock better. The setting depth is not limited as it is in a stationary barrel type, and the pressure is equalized. Slow strokes can be used as it can be fitted with close tolerance plungers. A choice of plungers can be had in cups, composition rings, flexible rings, chrome plated plungers for sand and abrasion, and hard cast nickel for corrosion and sand. This pump is very popular in the West Texas area in depths from 400 feet to 9000 feet and is also popular with the users of slow stroke hydraulic units. It offers a large selection of materials for all well conditions whether they be corrosive, sandy, gassy, or a combination.

Because of the small bore, this pump would not be efficient in lifting heavy fluids.

SPECIAL ROD PUMP

The special travelling barrel type rod pump is another of the special rod pumps designed to meet requirements of certain problem wells. The selection of plumger sizes range from 3/4-inch, 1-inch, 1-1/4-inch in 2-inch tubing to 1-1/2-inch and 1-3/4-inch in 2-1/2-inch tubing. This is a close fitted type pump capable of handling sand and it is excellent in low fluid level wells and small capacity wells. Many operators run this pump immediately behind a sand frac as it is close fitted and hard to stick when operating with ample fluid. It is the only small bore pump (3/4-inch) that can operate without the penalty of restricted ball and seat openings which usually decrease with the decrease in plunger size.

On this type pump, the smallest ball and seat used is a 1-1/4-inch and this is used only on the 3/4-inch bore pump. The 1-inch and 1-1/4-inch bore pumps use 1-1/2-inch ball and seat on plunger. The pump is a travelling barrel type and all of the previously listed advantages are available. Please note that this pump has the plunger directly connected to the holddown by an adapter and does not employ the use of a pull tube. This arrangement permits a very compact unit with fewer parts and fittings and, of course, lower repair costs.

DOUBLE DISPLACEMENT ROD PUMP

Double displacement rod pumps are recommended:

(1) Where is is desired to lift a greater volume of fluid in order to increase the daily oil production, and
(2) Where it is desired to produce the same volume of fluid, but at a slower rate.

The double displacement rod pump is an insert type, travelling barrel assembly consisting of two plungers and barrel tubes working simultaneously with a single set of valves. The two chambers within the pump are sealed off by a packing section around the connecting tube.

The effective plunger area of each size double displacement pump is greater than the largest tubing pump which can be used with any given size tubing. (The increase in plunger area is due to the combined displacement of two plungers).

There are a number of operating advantages which make the installation of double displacement pumps advantageous over tubing pumps or centrifugal pumps. Foremost is the fact that double displacement pumps afford all of the production advantages of such full volume pumps and the operating advantages of an insert type pump which can be run on the rods. Compared to a tubing pump of a given size, more fluid can be obtained at the same plunger travel with a double displacement pump, or the same volume of fluid can be obtained at slower pumping rates.

Double displacement pumps operate most efficiently in shallow field, or in wells with high operating fluid levels. These pumps also reduce operating costs by making it possible to slow down old or worn out pumping units. By operating a pumping jack at a slower speed its service life can be increased and maintenance cost can be reduced proportionately. Slower pumping speed also means longer rod life.

At this time it is well to remember the advantages of selecting primary pumps that later can be converted into double displacement pumps thereby lowering lifting costs considerably in the secondary stages.

The double displacement rod pump can eliminate the extra expense of buying larger tubing in cases where 2-1/2 inch tubing is already being used and 2-1/4-inch tubing pump, operating at a given number of strokes and SPM,

Constant for Comparing Theoretical Displacement

Type Pump	Tubing Size	Pump Bore	Connecting Tube Diameter	Equivalent Bore Diameter	Bore Area Square Inches	Constant "C"
Rod	2″	1$\frac{1}{16}$″	....	1.0625″	.887	.132
Rod	2″	1$\frac{1}{4}$″	....	1.2500″	1.227	.182
Rod	2″	1$\frac{1}{2}$″	....	1.5000″	1.767	.263
Double-Displacement	2″	1$\frac{1}{2}$″	1″ (Base)	1.871″	2.749	.408
Rod or Tubing	2$\frac{1}{2}$″	1$\frac{3}{4}$″	....	1.750″	2.405	.358
Tubing	2″	1$\frac{25}{32}$″	....	1.781″	2.492	.370
Rod	2$\frac{1}{2}$″	2″	....	2.000″	3.142	.465
Double-Displacement	2$\frac{1}{2}$″	2″	1$\frac{1}{4}$″ (—40)	2.556″	5.133	.762
Tubing	2$\frac{1}{2}$″	2$\frac{1}{4}$″	....	2.250″	3.976	.590
Rod	3″	2$\frac{1}{2}$″	....	2.500″	4.909	.732
Double-Displacement	3″	2$\frac{1}{2}$″	1$\frac{1}{2}$″ (Base)	3.202″	8.050	1.195
Tubing	3″	2$\frac{3}{4}$″	....	2.750″	5.940	.876
Rod	4″	3$\frac{1}{4}$″	....	3.250″	8.296	1.232
Double-Displacement	4″	3$\frac{1}{4}$″	2$\frac{1}{4}$″ (—40)	4.030″	12.756	1.894
Tubing	4″	3$\frac{3}{4}$″	....	3.750″	11.045	1.640
Double-Displacement	5″	3$\frac{3}{4}$″	2$\frac{1}{4}$″ (—40)	4.821″	18.253	2.711
Tubing	5″	4$\frac{3}{4}$″	....	4.750″	17.721	2.631

Displacement (Bbls./Day) = Constant "C" x Stroke (in inches) x Number Strokes Per Minute, or P = C x S x SPM

If in the displacement formula the polished rod stroke is used the result is the so-called apparent theoretical displacement. If the actual plunger stroke is used, as calculated or measured, the result is the actual theoretical displacement. Theoretical displacement assumes 100 per cent pump efficiency.

will produce 500 total barrels of fluid in 24 hours. When necessary to handle more fluid with this set up, a double displacement rod pump can be inserted and seated in the top of the tubing pump or seating nipple and 29 per cent more capacity can be obtained. In most cases, this will probably hold the production up for a considerable time and in some cases, it is the maximum that will be needed in this program. Double displacement pumps are made in various metals and plunger combinations to fit your well conditions.

Polish rod loads are increased when double displacement pumps are used, due to the greater volume of fluid being lifted. We are listing below the formula and constant necessary to calculate rod loads on this double displacement and other pumps.

GAS CHASER TYPE PUMP

This is a twin plunger pump designed to give the maximum in compression ratio. This ratio is accomplished by installing the secondary stage plunger and seal. In effect this carries the fluid load, thereby enabling the first stage or large primary stage to operate a better suction method to obtain maximum entry of gas, or fluid and gas mixed, into the primary chamber. From there the gas or mixture of fluid and gas goes into the secondary chamber where it is compressed into the smaller plunger and on out into the tubing when sufficient pressure has been built up to offset and overcome the hydrostatic head of fluid in the tubing.

In the case of fluid being handled without gas, the size of pump, in effect, is the diameter of the primary plunger. That fluid is merely compressed into the secondary plunger and moved right out into the tubing on each up stroke. In the event that gas is being compressed, it merely moves into the compression chamber; on each up stroke it is trapped in the secondary plunger until sufficient pressure is built up to overcome the hydrostatic head of fluid in the tubing. It then goes into the tubing and leaves the compression chamber clear to receive another load on the next up stroke.

Careful spacing is necessary in order to make this type most effective. A minimum of unswept area must be considered. This simply means each pump should be designed for the plunger to travel in a very carefully measured stroke at the bottom of the hole so that you have a minimum of unswept area on both the top and bottom of each stroke.