# Subsurface Pumps Can Be Fun

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Years ago, one could pick out the "pumpers" in a Saturday night, boom town crowd because their shirt tails were too short to meet their britches. In those days a piece of cloth was used under the tapered seat, of a ball and seat, to make a seal -- somewhat like the "patches" used to seal the lead balls in a Civil war rifle. Naturally, a shirt tail was the handiest place to get a piece of cloth and after a few trips the result was a very "short shirt."

The principle of the subsurface pump has changed little since those days. It is still just one tube moving over another -- a standing valve, a traveling valve and an up and down motion imparted by a "rod string." Today's pump however, consists of better material more accurately made and is better serviced.

Upon his retirement, a forty year veteran pump salesman claimed to be the only man who had installed a pump at the bottom of a well. In a shallow Pennsylvania field a hole with a 36 in. caisson was underreamed to an 8 ft circle. The bottom sloped toward a central sump. so a great number of holes were air drilled horizontally into the producing layer, and the thick oil would ooze out and down into the sump. This pump man had gone into the cavity and installed a tubing barrel and standing valve on the bottom of the tubing.

To him this installation was Fun; he actually installed a pump "at the bottom" of a well. Upon retiring, he remarked, that, should he be able to relive this career, he would again want to serve the oil business as a man who "knew his pumps"; but he would get more Fun out of his job.

Recently a committee making a report to a national association stated: "Subsurface pumps are the last stronghold of chaos, a mixture of hokum, by the makers; and confusion, at all levels, by the users." If this opinion still exists, it seems to be a problem in Communications. Apparently the maker-user problem here is to find a way to communicate: Why pumps are made as they are, and conversely, what the user needs to get the job done at reasonable cost.

Actually a pump is a simple set of pieces which screw together in such manner as to allow repair of any individual part that shows wear or damage.

It is assumed that the reader know pumps; therefore, there will be no need to review such items as the difference between a tubing pump and a rod pump or the manner by which a fluid seal, three-tube pump works. But the big problem that is faced is not that of complexity but that of making pumps strong enough to take the operational loads. Everyone wants to drill post hole wells, reduce tubing sizes, use slim hole couplings on sucker rods, and use rod type pumps.

New production zones are getting deeper and deeper, and down-the-well equipment has frequently been the most critically loaded material of all items used in the oilfield. Adequate factors of safety have long been abandoned and maximum loading applied; however, only through the use of the best possible material can tiny pumps be run -- to depths of 10,000 or 12,000 ft.

For instance, in the new API - 11AX the wall of a 1-1/2 in. bbl, for so called 2 in. tubing, has an OD of 1.760 in. maximum with ID of 1,500 in. Both walls would be total .260 in. maximum or just over 1/8 in. per wall, while threading is 1.573 in major diameter. Thus the wall remaining at the highly stressed threads is $(1.760-1.573) \div 2$ or .0935 in. less than 1/10 in.

It is hoped that the threading is exactly centered in the tube, that the fitting which is screwed into the barrel thread is not tight enough to distort the wall, and that there are no pipe wrench marks or other external damage.

Just for fun, this pump is run, top seated, in a 4500 ft oil plus water well. For every 2.31 ft of height fresh water creates 1 lb per sq in. pressure; salt water can create considerably more, if it is assumed that the water has a weight of 1 lb for every 2.25 ft: $4500 \div 2.25 = 2,000$ lb per sq in.

On the down stroke the column of fluid pushes out on the barrel walls; and contrary to this action a bottom seated pump has the column of fluid pushing "in" on the barrel. In this 1.500 in. barrel the stress, in the wall at the threads, becomes 16,050 lb per in. of metal. Now the shock of putting this load on and off the standing valve, as the pump operates, may be twice this load; but if a sucker rod breaks who knows what it might be.

The tensile strength of good alloy steel is about 100,000 lb per sq in; the yield point, however, is around only 78,000 lb. The column load, plus impact would be 32,000 lb per sq in. of wall material, while the customary 4 to 1 safety factor recommended for equipment placed a long and expensive way below the surface has dropped to 2.43 to 1.

So oil men have a split barrel now and then. What can be done about this situation? Well, here is where the Fun starts!

First: the pump is bottom seated. Then the barrel and fitting will not have to carry the tension type load surges to the standing valve. The pressure on the barrel will be external, not internal; and a pipe does not split from external pressure (but it may collapse.)

Second: the tube strength is increased, and made homegeneous (all at one material). The inner wall for plating is not cut away; it is better to use a heavy wall tube, requiring small bore and longer stroke.

Third: the pump is inhibited. Corrosion can reduce capacity of steel to carry loads; and it is generally agreed that a pump is hard to inhibit against corrosion because the inhibitor is wiped off by the moving surfaces.

Often there is a considerable difference in the materials of parts used in the pump, and this difference, creates galvanic local battery action. Keeping the materials as much alike as possible helps avoid these local batteries.

Many inhibitors float on water, so the inhibitors should be below the pump. Squeeze jobs, into the formation, are helping materially in this regard.

Pumping speed that creates bad harmonics should be avoided, and surface lines of adequate size should be used.

Another trend which has expensive implications, is that of "close fit" plungers.

Temperature in wells increase as depth increases, about $^{\circ}$F for every 50 ft (below about 150 ft and 50$^{\circ}$ Metals expand as temperature increases, although cast material expands less than steel and plated materials more. Thus, because of these differences in expansion effect, a pump which runs freely above ground may be very tight at the bottom of the well, but the slippage past the plunger lubricates the plunger, keeps down the heat caused by friction, and avoids dry metal to metal wear.

It will likely be found that a - .002 in. fit will be as tight, after a few weeks service, as a pump that started with a -.001 in. fit. One will avoid some of his stuck plunger pulling jobs; but with the looser fit, what is lost? Slippage will tend to reduce volume, but how much does between a - .001 in. and a - .002 in. plunger fit reduce it? It is less than 2/10 of one per cent, so to lose 1 BPD one would have to have a 500 bbl well, and the slippage difference vanishes quickly with time.

Just for Fun one can run a few checks on plunger and barrel wear versus fit.

Recently a customer insisted that his pump be fitted with "O" clearance; he wanted 1.500 in. minus nothing plunger in a 1.500 in. plus nothing barrel. However, the fitting could not be furnished for there existed no hydraulic press to force the plunger into the barrel, or to get it out again. This incident proves that "there's never a dull moment in this business."

Because pumps have been made more accurate, one should fit the plungers to take advantage of this fact and first try - .002 in. If volume efficiency is low, a - .003" (not - .001") fit should be tried and one might be surprised. So one should play around with his pumps and prove, by just using common horse sense, that reduced costs can be secured.

Another experiment that one can try is to determine the time to double valve. One should equip with double valve when one handles hard material -- sand, salt or abrasive gyp -- with his oil.

A seat cuts out when fluid under high pressure passes through a narrow orifice; thus when a grain of sand holds the ball off its seat such cutting can start.

If once in 1,000 strokes, a tiny grain of sand is under the traveling ball then one should double valve, for the chance of having both balls held open, on a single stroke, is one in a million strokes.

If either ball is seated no flow occurs and hence there is no "wire" cutting of the seat in the open valve. It should be remembered that some balls and seats cost less per pair than do other single set ups. One can have some fun solving this problem.

Despite an awful array of trade names which do add confusion for sure there are only a few manufacturers of balls and seats. Most grades are similiar and of six general types: tool steel, hard bronze, stainless steel, monel, stellite, and (sintered) tungston carbide. They appear in the chart.

Incidentally, if one has to pump a few hours and shut down a few hours -- thanks to proration or otherwise -- and one has sand to handle, he should put a sand check (drop and seat) in the top guide, around the valve rod. Sand settling out of the fluid column cannot then enter the barrel. The check is cheap insurance, for the valve rod guide-cage is bought anyway.

Generally the harder the barrel and plunger combination the less it wears. But one should avoid similiar materials in the plunger and the barrel. For instance, a casting against fabricated steel should be used, or plated (Or hard surfaced) material against either fabricated steel or cast material.

The borides, cast or laid on with a torch, have a very low coefficient of friction. But they are slippery rascals, for these and these only can frequently be run against each other. However, they are at the top of the scale in hardness, and also in corrosion resistance, and when used together they expand uniformly under unceasing heat and avoid changes in fit as the pump is lowered.

If one has to pump a newly sand-fraced well, or has a well that produces what seems to be more sand than oil, then he should not overlook the three-tube sand pump. This pump depends on very loose clearances (about .0015 in.) and a fluid seal in the long double seal areas. To assist in holding these fluid seals the pump should be about double the length of a standard traveling tube pump.

Generally speaking a traveling tube type pump is simple: it has heavier moving parts, often falls easier and takes a slightly bigger "bite" of fluid. When one is utilized a hard "wear band" is used near the top to act as a guide.

If one has a gyp condition, extensions should be used above and below the pump barrel, and the plunger should stroke out both ends of the barrel. Then if a valve fails to close on one stroke the plunger cannot enter a "gipped" area of the barrel and stick the pump.

Fabric cup or ring plungers work well in large water wells, for they can be "redressed" easily. They sometimes fail with little warning, while metal plungers decline slowly in volume and allow time to plan economic pulling crew operations.

The Selection Chart is a rough guide to better pumping. It is not guaranteed; but it was fun making it. Perhaps some chaos and confusion can be eliminated by its use.

If the pump problem is a gassy well, the following suggestions assist in avoiding gas lock.

A gas valve is installed on the lower end of the plunger, and the standing valve and the gas valve are brought as closely together as possible. Thus little space is allowed for the compressed gas, and much of it is forced through the traveling valve, This operation is accomplished with greater ease in a traveling barrel type pump.

A simple way (one might try this, just for kicks) to rid a pump of gas would be to drill a few holes in the barrel just under the plunger position at the top of its stroke. Gas would rush out these holes, as the plunger passes them, while already produced oil would come in the holes and fill the barrel below the plunger. Of course, the holes would "cut out" with time but one stops his "gas lock."

There are many ideas like this which could make "pumping" a "hobby" and lots of real Fun.

One last thought: If the other fellows job seems more interesting and more fun and the pasture on the other side of the fence seems greener, remember this: your pasture could be just as green; - all that it takes is that old fertilizer. So let's have fun in our own field and forget the Chaos and the Confusion.

## SUBSURFACE ROD PUMP SELECTION CHART

Application of Fittings

CARBON STEEL: Noncorrosive, medium-depth, and shallow wells
NICKEL-ALLOY STEEL: Hydrogen sulphide, mild carbon dioxide, brine, deep wells and heavily loaded wells
STAINLESS STEEL: Severe carbon dioxide, deep wells, heavy pumping loads and brine

| Well Conditions | ROD PUMPS | | | | Barrel and Plunger | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Stationary Barrel | | Travel-ing Barrel | Three Tube | Full Barrel | | | | | |
| | Top Hold-Down | Bottom Hold-Down | | | Cold Drawn Carbon Steel | | Chrome Plated I.D. | | Hardened low Alloy Steel | |
| | | | | | Type Plunger | Symbol | Type Plunger | Symbol | Type Plunger | Symbol |
| To: 3,000 Feet | | | | | | | | | | |
| Crooked Hole | 1 | 3 | | | C | | D | | C | 1 |
| Large Volume | | | 2 | | D,C | 2 | D | 3 | C | 1 |
| Low Fluid Level | 1 | | | | D,C | 1 | D | 2 | C | 1 |
| Normal and Straight Hole | 1 | 2 | 2 | | D,C | 1 | D | 2 | D | 2 |
| Medium Sand | 1 | | 3 | 1 | | 3 | A | 1 | C | 1 |
| Extreme Sand | 2 | | 3 | 1 | | | A | 1 | A,C | 1 |
| Brine | 1 | 3 | 1 | | B | 3 | | | B,C | 1 |
| Considerable Gas | 2 | | 1 | | D | 3 | D,E | 2 | D,E | 1 |
| Hydrogen Sulphide | 3 | 2 | 2 | | | | | | A | 1 |
| Carbon Dioxide | 2 | 2 | 2 | | | | A | 1 | D,C | 2 |
| Medium Sand and Medium Corrosion | 2 | 3 | 3 | 1 | | | A | 1 | D,C | 2 |
| Extreme Sand and Extreme Corrosion | 1 | | 3 | | | | E | 1 | A | 2 |
| 3,000 to 5,000 Feet | | | | | | | | | | |
| Crooked Hole | 1 | 3 | | | C | 1 | | 1 | C | 1 |
| Large Volume, | 2 | 2 | 1 | | D,C | 2 | D | 2 | D | 1 |
| Low Fluid Level | 1 | 2 | | | D,C | 2 | D | 2 | C | 1 |
| Normal and Straight Hole | 1 | 1 | 3 | | D,C | 1 | D | 1 | D | 1 |
| Medium Sand | 2 | | 3 | 1 | D,C | 3 | A | 2 | D,C | 2 |
| Extreme Sand | 2 | | 3 | 1 | | | A,E | 1 | A,E | 2 |
| Brine | 1 | 3 | 1 | | B | 3 | | | D | 2 |
| Considerable Gas | 2 | | | | D | 3 | D,E | 2 | D,E | 1 |
| Hydrogen Sulphide | 3 | 1 | 2 | | | | | | D*E | 2 |
| Carbon Dioxide | 2 | 1 | 1 | | | | A | 1 | C | 3 |
| Medium Sand and Medium Corrosion | 1 | 2 | 2 | 1 | | | A | 2 | D*E | 2 |
| Extreme Sand and Extreme Corrosion | 1 | | 3 | | | | A | 3 | A*E | 2 |
| 5,000 to 7,000 Feet | | | | | | | | | | |
| Crooked Hole | 1 | 3 | | | C | 3 | A | 2 | C | 1 |
| Large Volume | 1 | 3 | 1 | | D,C | 3 | D | 1 | D,C | 1 |
| Low Fluid Level | 1 | 2 | | | D,C | 3 | D | 1 | D,C | 1 |
| Normal and Straight Hole | 2 | 1 | 1 | | D,C | 2 | D | 2 | D,C | 1 |
| Medium Sand | 2 | | 2 | 1 | | | E | 2 | C,E• | 1 |
| Extreme Sand | 2 | | 3 | 1 | | | E | 1 | E | 1 |
| Brine | 1 | 1 | 1 | | | | B,E | 1 | D,E• | 1 |
| Considerable Gas | | 2 | 1 | | | | D,E | 2 | D,E | 1 |
| Hydrogen Sulphide | | 2 | 1 | | | | | | D• | 2 |
| Carbon Dioxide | 3 | 1 | 1 | | | | A | 1 | C• | 3 |
| Medium Sand and Medium Corrosion | 2 | 2 | 1 | 1 | | | E,A | 2 | D | 1 |
| Extreme Sand and Extreme Corrosion | 2 | 1 | 3 | | | | A | 2 | C | 2 |
| Below 7,000 Feet fi | | Bottom Hold Down Top Seal | | | | | | | | |
| Crooked Hole | | 1 | | | | | | | C,E• | 1 |
| Large Volume | | 1 | 2 | | | | E,A• | 1 | C,E• | 1 |
| Low Fluid Level | | 1 | | | | | E,A• | 1 | C,E• | 1 |
| Normal and Straight Hole | | 1 | 3 | | | | E,A• | 2 | C,E• | 2 |
| Medium Sand | | 1 | | | | | E,A• | 1 | C,A•E | 1 |
| Extreme Sand | | 1 | | | | | | | A•E | 1 |
| Brine | | 1 | 3 | | | | | | A•E | 1 |
| Considerable Gas | | 2 | 1 | | | | A,E• | 2 | A•E | 1 |
| Hydrogen Sulphide | | 1 | 3 | | | | | | A•E | 2 |
| Carbon Dioxide | | 1 | 3 | | | | A• | 2 | A• | 3 |
| Medium Sand and Medium Corrosion | | 1 | | | | | A•E | 1 | A•E | 1 |
| Extreme Sand and Extreme Corrosion | | 1 | | | | | | | | |

The Following Symbols Indicate Type of Pump Recommended:

- 1 - Gives Outstanding Service
- 2 - Widely Favored
- 3 - Often Used
- * - Heavy Wall Barrel Recommended
- +- Stainless Alloy Iron Liners
- fi - Top Sealing and Bottom Hold-Down Recommended Below 7,000 Feet

The Following Letters Indicate Type of Plunger:

- A - Cast Boron Alloy Iron (Sectional)
- B - Fabric Ring or Cup
- C - Chrome Plated
- D - Cast Nickel Iron (Sectional)
- E - Hard Surface Spray Welded Alloy

| Combinations | | | | | | Standing Valve | | Balls and Seats | | | | | | Use Sand Check Cage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sectional Liner Barrel | | | | | | | | | | | | |
| Hardened High Alloy Steel | | Hard Cast Iron | | Cast Alloy Iron | | | | Tool Steel | Stainless Steel | Hardened Bronze | Monel Metal | Stellite | Tungsten Carbide | |
| Type Plunger | Symbol | Type Plunger | Symbol | Type Plunger | Symbol | Single | Double | | | | | | | |
| C | 2 | C | 3 | A,C | 2 | 1 | 2 | 2 | 1 | | | | 3 | |
| D | 2 | C | 2 | A,C | 3 | 2 | 1 | 2 | 2 | | | | 1 | |
| D-C | 2 | C | 2 | A,C | 2 | 2 | 1 | 2 | 2 | | | | 2 | |
| D-C | 3 | C | 3 | A,C | 3 | 1 | 2 | 1 | 1 | | | 2 | | |
| E-C | 1 | E | 3 | A,E | 1 | 2 | 1 | 1 | 1 | | | 1 | 2 | |
| E-C* | 1 | | | A,C | 2 | 3 | 1 | 2 | 2 | | | 2 | 1 | Yes |
| D,A* | 1 | B,D | 3 | A,E | 2 | 1 | 2 | 2 | 2 | 1 | 3 | 2 | 3 | Yes |
| D,E | 1 | | | | | 3 | 1 | 2 | 1 | | | 3 | | |
| E,A* | 1 | | 3 | A | 2 | 2 | 1 | | | | 2 | 1 | 1 | |
| | | C | 3 | A-C + | 1 | 2 | 1 | 3 | 1 | | 2 | | 2 | |
| E,A* | 1 | C | 3 | E-C | 1 | 2 | 1 | 3 | | | | 1 | 2 | Yes |
| E,A* | 2 | | | E-C + | 1 | 2 | 1 | 3 | 3 | | | 2 | 1 | Yes |
| C | 1 | | | C | 2 | 1 | 2 | 1 | 1 | | | 1 | 3 | |
| D-A | 1 | | | A-C | 2 | 2 | 1 | 2 | 1 | | | 1 | 2 | |
| D-C | 1 | C | 1 | A,C | 2 | 1 | 3 | 1 | 1 | | | | 3 | |
| D-C | 2 | C | 2 | A,C | 2 | 1 | 3 | 1 | 1 | | | 2 | 2 | |
| D-C* | 1 | C,AE | 3 | A,C | 2 | 2 | 1 | 1 | 1 | | | 2 | 1 | Yes |
| D-C* | 1 | | | A,C | 1 | 3 | 1 | 2 | 2 | | | 2 | 1 | Yes |
| D-A*B | 2 | D,A,B | 2 | A,E | 1 | 3 | 1 | | | 1 | 2 | 1 | 2 | |
| A,E | 1 | | | | | 3 | 1 | 2 | 1 | | | 3 | | |
| D-A* | 3 | A,E | 2 | E | 1 | 3 | 1 | | | | 2 | 1 | 2 | |
| | | C | 3 | C+ | 1 | 2 | 1 | | 1 | | 3 | | 1 | |
| D-A* | 2 | C | 3 | A,C | 1 | 2 | 1 | 3 | | | | 1 | 2 | Yes |
| D-A* | 2 | | | A-C+ | 1 | 2 | 1 | 3 | | | | 1 | 2 | Yes |
| C | 1 | | | A,C,E | 2 | 2 | 2 | | 3 | | | 2 | 1 | |
| C-A | 1 | C | 2 | A,C,E | 1 | 2 | 1 | | 2 | | | 2 | 1 | |
| D-C | 1 | C | 2 | A,C,E | 1 | 2 | 2 | | 3 | | | 2 | 1 | |
| D,C | 1 | C | 2 | A,C,E | 1 | 2 | 2 | | 3 | | | 2 | 1 | |
| A-C*E | 1 | C | 2 | A,C,E | 1 | 2 | 1 | 2 | | | | 2 | 1 | Yes |
| C-A*E | 1 | C | 3 | A,C,E | 1 | 2 | 1 | 3 | | | | 2 | 1 | Yes |
| B-A*E | 2 | | | A,E | 1 | 2 | 1 | | | 1 | 3 | | 1 | |
| A,E | 1 | | | | | 3 | 1 | | 1 | | | 2 | 3 | |
| D-A*E | 2 | A-E | 3 | A,E | 1 | 2 | 2 | | | | 3 | 2 | 1 | |
| A,E | | C-E | 3 | C,A + | 1 | 2 | 2 | | 1 | | | | 1 | |
| D-A* | 1 | A-C,E | 3 | A-C,E | 1 | 2 | 1 | 3 | | | | 2 | 1 | Yes |
| D-A*E | 2 | | | A-C + | 1 | 2 | 1 | 3 | | | | 3 | 1 | Yes |
| C*E | 1 | | | A,C,E | 2 | 2 | 1 | | 2 | | | 1 | 1 | |
| C*E | 1 | | | A,C,E | 1 | 3 | 1 | | 3 | | | 2 | 1 | |
| C*E | 1 | | | A,C,E | 1 | 2 | 1 | | 3 | | | 3 | 1 | |
| C*E | 1 | | | A,C,E | 2 | 2 | 1 | | 3 | | | 2 | 1 | |
| C,A*E | 1 | | | A.C,E | 1 | 3 | 1 | 3 | | | | 2 | 1 | Yes |
| A*E | 1 | | | A,C,E | 1 | 3 | 1 | | | | | 3 | 1 | Yes |
| A*E | 1 | | | A,E | 1 | 3 | 1 | | | 3 | | 2 | 1 | |
| A*E | 1 | | | | | 3 | 1 | | 3 | | | 2 | 1 | |
| A*E | 3 | | | A,E | 1 | 3 | 1 | | | | | 3 | 1 | |
| | | | | C-A + | 1 | 3 | 1 | | 2 | | | 3 | 1 | |
| A-C*E | 1 | | | A,C,E | 1 | 3 | 1 | | | | | 3 | 1 | Yes |
| A-*E | 1 | | | A E+ | 1 | 3 | 1 | | | | | 3 | 1 | Yes |