Selection of Subsurface Pumping Equipment

By J. E. GALLIAN

Continental-Emsco Company

There is an almost infinite variety of subsurface pumps available to the producer of today. He can select from two basic styles of rod-actuated insert pumps, traveling or stationary barrel, with numerous variations in construction and material combinations. There are tubing pumps of various constructions and materials; casing-type pumps are closely akin to tubing pumps in their size and basic construction, but still have one feature of the insert pump in that the whole assembly is run and retrieved with the sucker rod string.

He may choose from hydraulic systems with almost as many variations in construction and materials as the rod actuated pumps and available as either insert pumps or casing pumps. They can be actuated by either power oil or treated water. Some assemblies can be pumped out by reversing the path of the power fluid while others are retrieved with wire lines.

Or he can select either submersible turbines or centrifugal pumps, which are capable of handling tremendous volumes of fluid. These are also available in many combinations of materials to combat various well conditions.

There is also a great variety of gas lift systems. While gas lift is not a pumping operation in the strict sense, it is still a method of artificially lifting fluids from a well.

So you can see there is a bewildering array of artificial producing equipment available to the producer. Each has its place in the oil industry and when properly selected and applied, can quite often mean the difference between profit and loss. To cover each of these various systems and their many ramifications would take days or even weeks; consequently, this paper will cover only some of the factors that should be considered in making an initial selection of pumping equipment.

The first factor is depth. This is one value that is always known and it has the greatest impact on which type of system is selected. Second is volume, which is almost, if not equally, important. If the well in question is 8000 feet or less, a sucker rod system is recommended. This, of course, would be contingent on the fluid volume to be handled. Large volumes can be handled economically by rod systems in the two to three thousand foot range. Below this, the fluid capacities for economical operations begin to decline rapidly. The prospect of lifting 300 or more barrels from 5000 feet or more would cause one to inquire into the cost and maintenance of some other system. With any system, the volume that can be handled profitably declines proportionally with the increase in depth; however, some systems, such as hydraulics and submersibles, do not have the same decline ratio as the rod pumps. In some cases (high fluid

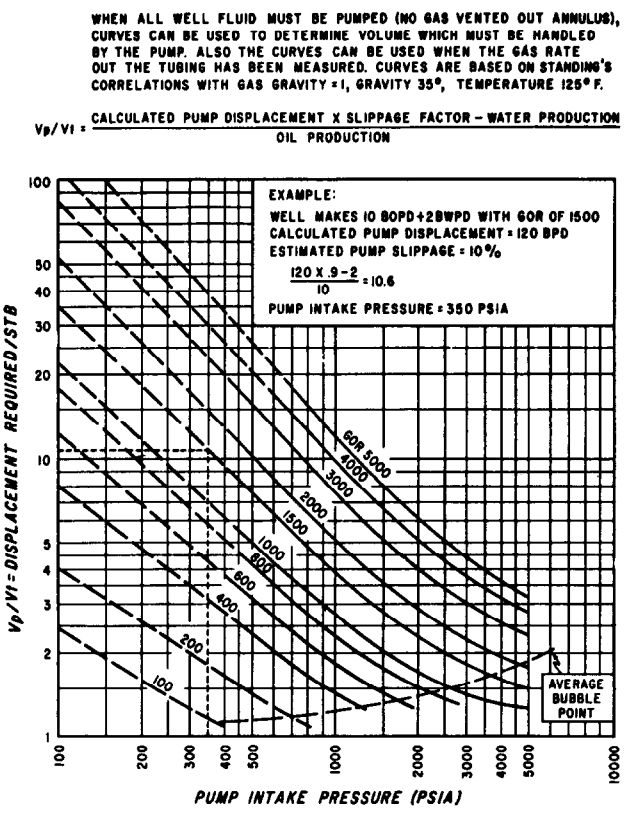

FIGURE 1.—Pump Displacement Required per Barrel of Oil in Stock Tank.

levels and available low cost) high-pressure gas might dictate the use of one of the several gas lift systems.

Assume that the depth and volume required have indicated a rod pump to be the most economical and practical for this application. Now we are faced with selecting the proper subsurface pump. Ignore the sizing of the unit, rods and prime mover since they are calculated from precise formulae, which leave little, if anything, to chance when depth and volume are known.

Now, again consider such factors as depth, as this will dictate whether a top or bottom hold-down can be used. Also, the type of bottom hold-down, mechanical or cup, is decided by depth. Depth plays an important part in deciding between a traveling barrel (R-T) or stationary barrel (R-B or A). Up to 5000 feet, a thin-wall barrel with either top or bottom cup hold-down, and either stationary or traveling barrel pumps

TABLE 1

Material Application Guide for Pump Barrels

Corrosion Media	Monel	Monel Plated Cr.	70-30 Brass	85-15 Brass	Admiralty Brass	70-30 Brass Plated	85-15 Brass Plated	Admiralty Plated	Nitralloy-N Nit.	440-C Liners	4-6 Chrome Carbo.	C-1020 Carbo. Nit.	HCI Liners	1020 Soft	1020 Plated
(1) Severe H_2S	A	C	B	C	B	C	C	C	C	C	C	C	C	C	C
(2) Mild H_2S	A	B	B	C	B	B	C	B	B	C	C	C	B	C	C
(3) Severe CO_2	B	C	C	A	B	C	B	B	C	B	C	C	C	C	C
(4) Mild CO_2	B	B	C	A	B	C	B	B	C	B	B	C	B	C	C
(5) Severe Brine	A	A	C	A	A	C	A	A	B	B	B	B	B	B	C
(6) Mild Brine	A	A	C	A	A	C	A	A	A	A	A	A	A	B	B
(7) Oxygen	A	A	C	A	A	C	A	A	B	A	B	C	B	C	B

Definition - Corrosion Media

(1) Weight loss severe, high percentage H_2S and producing brine.
(2) Weight loss corrosion mild, producing H_2S and high volume brine.
(3) Weight loss high and/or severe pitting, producing high percentage CO_2 and some brine.
(4) Weight loss mild and/or mild pitting, producing small amount CO_2 and large volume brine.
(5) No H_2S or CO_2, producing more than 50% brine.
(6) No H_2S or CO_2, producing less than 50% brine.
(7) Usually encountered in water flood area.

"A" - Material should be suitable under most conditions of use.
"B" - Corrosion may be expected, but the material should be suitable under some conditions
"C" - Corrosion will usually be too severe for successful use.

can be used with good results. Below this the use of a heavier-wall barrel or a liner-type pump is suggested. Thin-wall barrels on stationary pumps with bottom hold-downs are commonly used with good life to 8000 feet, but there is danger of splitting the barrel at below 5000 feet if the well pounds fluid and the inside of the barrel cannot be filled to equalize with the hydrostatic head on the outside. The author does not recommend the use of traveling barrel pumps below 5000 feet as the usual rule because of external wear on both tubing and barrel. The pumps applied at this depth are usually 16 feet or more in length to accommodate the longer and slower strokes of the pumping unit. This involves the use of a long pull tube, which is subject to considerable bending movement at the hold-down connection plus the wear mentioned before. Also, the gas-handling capability of a traveling barrel pump is less than that of the stationary barrel pump.

Below 5000 feet, the use of an API bottom lock hold-down should be seriously considered.

TABLE 2
Material Application Guide for Metal Plungers

	Hardened Steel	Chrome Plated	Hardened & Chrome Plated	Lubri-Chrome	Duralloy*	Duralloy*, Monel Pin End	HCI Plunger Sections	Reliance* Plunger Sections
(1) Severe H_2S	C	C	C	B	B	A	C	B
(2) Mild H_2S	B	C	C	A	A	A	B	A
(3) Severe CO_2	B	B	B	B	B	A	B	B
(4) Mild CO_2	B	B	B	A	A	A	A	A
(5) Severe Brine	B	B	B	A	A	A	B	A
(6) Mild Brine	A	A	A	A	A	A	A	A
(7) Oxygen	B	A	A	A	A	A	A	A
(8) Abrasion	B	A	A	A	A	A	B	A

Definitions - Environmental Conditions

(1) Weight loss severe, high percentage H_2S and producing brine.
(2) Weight loss corrosion mild, producing H_2S and high volume brine.
(3) Weight loss high and/or severe pitting, producing high percentage CO_2 and some brine.
(4) Weight loss mild and/or mild pitting, producing small amount of CO_2 and large volume brine.
(5) No H_2S or CO_2, producing more than 50% brine.
(6) No H_2S or CO_2, producing less than 50% brine.
(7) Usually encountered in water flood area.
(8) Sand, Gyp, Scale, etc.

"A" -- Material should be suitable under most conditions of use.
"B" -- Damage may be expected, but the material should be suitable under some conditions.
"C" -- Condition will usually be too severe for successful use.

*Trade names, Continental-Emsco.

This hold-down locks with spring fingers under a recess and seals by means of a softer brass tapered ring against a hard steel mating seat. Since the seal O.D. is the same as the barrel, it is not necessary to overcome the hydrostatic head pressure on the cups to unseat the pump. Sometimes rods are permanently damaged by pulling hard enough to overcome this force plus the friction of the cups in the seating nipple. Gas anchor connections are provided on the bottom lock shoe so the benefits of a gas anchor are not lost in using this hold-down. Since the API bottom lock does not have an oversized No-Go, it helps to combat minor sand or trash problems in unseating.

Assume now that the type pump and hold-down have been selected. The type of fluid to be produced must now be considered. Is it corrosive? Abrasive? or both? High water cut? Gassy? Is gyp or scale present? These factors will dictate the materials to be used except that the gas and scales will also have a bearing on the construction. Table 1 will assist in selecting the proper barrel for corrosion, the designation of A being the best, B acceptable and C unsatisfactory.

If abrasion is also present, it may be necessary to sacrifice corrosion control for abrasion control, considering that the harder internal surfaces, such as plated or nitrided, are the best for abrasion. This is a judgment decision and may require the use of a trial and error method. However, the use of this application guide will help minimize the errors.

TABLE 3 — PLUNGER — BARREL SELECTION CHART
(Known Well Conditions)

WELL CONDITION	REGULAR DURA "C"	DURA "C"	DURA "N"	CHROME PLATED STEEL DURA "C"	REGULAR BRASS DURA "B"	CHROME PLATED BRASS DURA "B"	MONEL DURA "M"	CHROME PLATED MONEL DURA "M"	ACR (4-6 Cr.) CASE,TUBE	HCI LINERS	ENDURALL LINERS
SEVERE H_2S CORROSION Weight loss severe, High percentage H_2S and producing brine.					1B,3B,4B, 7B		4A,7B,3B,1B	4B,7B			
MILD H_2S Weight loss mild, producing H_2S and brine.			3B,4B,6B,7B		1B,3B,4B, 6B,7B	1B,3B,4B,6B 7B	6B,1A,3A,4A, 7A	1B,3B,4A,6B, 7A		3B,7B	
SEVERE CO_2 Weight loss high and/or severe pitting, producing high percentage CO_2 and brine.					1B,3B,4B, 7B	3B,4B,7B	1B,3B,4B,7B				7B
MILD CO_2 Weight loss mild and/or mild pitting. Producing small amount CO_2 and large volume brine.					1B,3B,4B, 6B,7B	1B,3B,4B,6B, 7B	1A,3B,4A,6B, 7A	1B,3B,4A,6B, 7A	3B,4B,6B, 7B	3B,7B,	3B,6B,7B
SEVERE BRINE No H_2S or CO_2. Producing more than 50% brine.	1B,6B,2B	3B,6B,7B	3B,4B,6B,7B		1A,3A,4A, 6B,7A	1A,3A,4A, 6B,7A	1A,3A,4A,6B, 7A	1A,3A,4A,6B, 7A	2B,3B,4B, 6B,7B	2B,3B, 7B	2B,3B,6B, 7B
MILD BRINE No H_2S or CO_2. Producing less than 50% brine.	1A,2A,6A	2A,3A,6A, 7A	2A,3A,4A,6A, 7A	1A,3A,6A,7A	1A,3A,4A, 6A,7A	1A,3A,4A, 6A,7A	1A,3A,6A,7A, 4A	1A,3A,4A,6A, 7A	2A,3A,4A, 6A,7A	2B,3A, 7A	2A,3A,6A, 7A
OXYGEN Usually encountered in water-flood areas.	1B,6B	6B,7B,3B			1A,3A,4A, 6B,7A	1A,3A,4A, 6B,7A	1A,3A,4A, 6A,7A	1A,3A,4A,6D, 7A	2B,3B,4B, 6B,7B	2B,3B, 7B	2B,3A,6B, 7A
NORMAL CRUDE No corrosion and no abrasion	1A,2A,6A	2A,3A,6A, 7A	2A,3A,4A,6B, 7A	1A,3A,6A,7A	1A,3A,4A, 6A,7A	1A,3A,4A, 6A,7A	1A,3A,6A, 6A,7A	1A,3A,4A,6A, 7A	2A,3A,4A, 6A,7A	2A,3A, 7A	2A,3A,6A, 7A
MODERATE SAND		6,2,3,7	6,2,3,4,7	6,3,7		6,3,7,4		6,3,4,7	6,2,3,4,7	2,3,7	6,2,3,7
EXTREME SAND		2,3,7	2,3,4,7	3,7		3,7,4		3,4,7	2,3,4,7		2,3,7

INDEX TO PLUNGERS, PLUNGER SECTIONS
CHART #1

1. Soft Packed
2. Chrome Plated Steel *
3. Duralloy
4. Duralloy with Monel Pins
5. Chrome Plated Stainless
6. HCI Sections
7. Reliance Sections

* The etched Moly Coated Chrome Plunger may also be used and meet same well conditions with special features for increasing service life. These features are: thicker chrome plate, etched and Moly coated for improving lubricating properties, and resistance to wear.

SUITABILITY OF MATERIAL

A. Material should be suitable under most conditions of use.

B. Corrosion may be expected, but materials should be suitable under some conditions.

Table 2 will assist in selecting the best plunger to run in the barrel selected. We apologize for the use of trade names here, but after all, Continental-Emsco is a manufacturing and sales company and this chart was prepared by our metallurgist for our sales people. Lubri-chrome is a chrome plating, electrically etched and coated with molybdenum di-sulphide. "Duralloy" is a nickel boron coating more commonly known as colomony. "Reliance" is a trade name for eutectic nickel iron castings. Here again one must weigh abrasion against corrosion. Chrome plate is the hardest at 72 Rc, eutectic nickel iron at 62 Rc and colmonoy at 60 Rc hardness.

Tables 3 and 4 combine the recommendations for both barrel and plungers for corrosion and abrasion. Generally speaking, the cages and fittings should be of the same material as the barrel while the cast carbide or tungsten carbide balls and seats are recommended for all but the clean, sweet-fluid wells.

Whenever possible, we recommend the use of a stroke-thru pump to combat any sand or scaling conditions. The exception to this is when gas imposes a problem. With GFR in excess of 1000:1 a full barrel pump, single valved with excellent close spacing between the traveling and standing valve is the best selection. Figure 1, which is a reproduction of a chart presented in a paper by J. D. Clegg of Shell Oil Company in 1963 at the West Texas Oil Lifting Short Course, will assist in selecting the bore of the pump where gas cannot be vented. In cases where gases cannot be separated successfully, specialized pumps, which act like a two-stage gas compressor, are available. These pumps actually handle gas as a liquid.

In conclusion, we suggest that you, as a producer, before selecting your artificial lifting equipment, consult with the manufacturing representatives of the four major methods of lifting. These people have devoted the major portion of their careers to studying the problems of producing oil. They can be invaluable in assisting you to better profits.

TABLE 4 — PLUNGER — BARREL SELECTION CHART
(Material Combinations)

BARRELS & LINERS	PLUNGERS AND PLUNGER SECTIONS: SOFT PACKED	CHROME* PLATED STEEL	DURALLOY	NCI SECTIONS	RELIANCE SECTIONS
REGULAR STEEL, DURA "G"	8a,7b,6a, 5b	8a,6a,5b		8a,7b,6a, 5b	
DURA "C"		8a,6a,B	8a,6a,5b, 7b,B	8a,7b,6a, 5b,A	8a,7b,6a, 5b,B
DURA "T"		8a,6a,B	8a,6a,5b, 7b,B	8a,6a,5b, 7b,A	8a,6a,5b, 7b,B
CHROME PLATED REGULAR STEEL, DURA "G" PLATED	8a,6a		8a,6a,B	8a,6a,A	8a,6a,B
REGULAR BRASS, DURA "B"	8a,7a,6a, 5a,4b,3b, 2b, 1b		8a,7a,6a, 5a,4b,3b, 2b,1b	8a,7b,6a, 5b,4b,2b	8a,7a,6a, 5a,4b,3b, 2b,1b
CHROME PLATED BRASS DURA "B" PLATED	8a,7a,6a, 5a,4b,2b		8a,7a,6a, 5a,4b,3b, 2b,B	8a,7b,6a, 5b,4b,2b, A	8a,7a,6a, 5a,4b,3b, 2b,B
MONEL DURA "M"	8a,7a,6a, 5a,4a,3b, 2a,1b		8a,7a,6a, 5a,4b,3b, 2a,1b	8a,7a,6a, 5b,4b,2b	8a,7a,6a, 5a,4a,3b, 2a,1b
CHROME PLATED MONEL DURA "M" PLATED	8a,7a,6a, 5a,4b,2b		8a,7a,6a, 5a,4b,2b, 1b,B	8a,7b,6a, 5b,4b,2b, A	8a,7a,6a, 5a,4a,2a, 1b,B
ACR (4-6 CHROME) CARBURIZED TUBE		8a,7b,6a, 5b,B	8a,7b,6a, 5b,4b,B	8a,7b,6a, 5b,4b,A	8a,7b,6a, 5b,4b,B
NCI LINERS		8a,7b,6b, 5b,A	8a,7b,6a, 5b,4b,2b, A		8a,7b,6a, 5b,4b,2b, A
CARBOBALL LINERS		8a,7b,6a, 5b,B	8a,7a,6a, 5b,4b,B	8a,7b,6a, 5b,4b,A	8a,7a,6a, 5b,4b,3b, B

WELL CONDITION

1. Severe H_2S Corrosion - Weight loss severe, high percentage H_2S and producing brine.
2. Mild H_2S - Weight loss mild, producing H_2S and high volume brine.
3. Severe CO_2 - Weight loss high and/or severe pitting, producing high percentage CO_2 and some brine.
4. Mild CO_2 - Weight loss mild and/or mild pitting. Producing small amount of CO_2 and large volume brine.
5. Severe Brine - No H_2S or CO_2. Producing more than 50% brine.
6. Mild Brine - No H_2S or CO_2. Producing less than 50% brine.
7. Oxygen - Usually encountered in water-flood areas.
8. Normal Crude - No corrosion and no abrasion.

A. Moderate Sand.

B. Extreme Sand.

a. Material should be suitable under most conditions of use.

b. Corrosion may be expected, but the material should be suitable under some conditions.

* The Etched-Moly Coated Chrome Plated Plungers would meet these well conditions with special features for increasing service life. These features are: thicker chrome plate, etched and moly coated for improving lubricating properties, and resistance to wear.