The Lease Pumper’s Handbook

Chapter 6
Mechanical Lift

Section D

THE DOWNHOLE PUMP

In a mechanical lift system, a pump of some configuration is required to transfer the oil from the production zone to the surface. Several styles of pumps are used, but they all have the same basic components. The styles of pumps are then distinguished from each other by the way the components are assembled and how they function. This section focuses on the similarities and differences among the basic styles of mechanical lift pumps.

D-1. Basic Components of the Pump.

The five basic components of downhole pumps are:

- Standing valve.
- Barrel tube.
- Plunger.
- Traveling valve.
- Holddown seal assembly.

Standing valve. The standing valve, at the bottom of the pump, is a one-way valve that allows fluid to flow from the formation into the barrel. A standing valve consists of a ball that rests on a narrow-lipped seat (Figure 1). This ball and seat assembly is contained in a valve cage with the ball on top or up as it is installed in the well. Pressure from below can unseat the ball and allow fluid to move past the valve. However, pressure from above keeps the ball seated so that fluid does not leak back past the valve.

Figure 1. Components of a ball and seat standing valve.
(courtesy of Harbison Fischer)

The ball and seat are finished to seal against each other as a set and sealed together as a unit. These paired components should always be kept together. Two sizes of balls are available with each size of seat. These are the standard American Petroleum Institute (API) size and a smaller alternate size that allows viscous fluids and debris to pass between the valve guides and the ball. Occasionally double valves are installed to try to solve specific problems.

Barrel tube. The barrel is the portion of the pump into which fluid from the formation flows. The barrel may be a separate component that is inserted into the tubing or it may be a portion of the tubing, depending on the pump design. Otherwise the principal differences between different barrels is the type and thickness of metal used and how the barrel accommodates the plunger used. Typically, pump barrel tubes are available in three thicknesses: thin wall, standard wall, and heavy wall. The wall material may be various grades of carbon steel, stainless steel, brass, or Monel and may have chrome plating. The metal may also be treated for protection against corrosion and chemicals and hardened for extra strength.

The barrel tubing must be machined for the installation. This will include the thread design and the proper clearances for the type of plunger used. Some pumps also use liners, which must be accommodated in the barrel design.

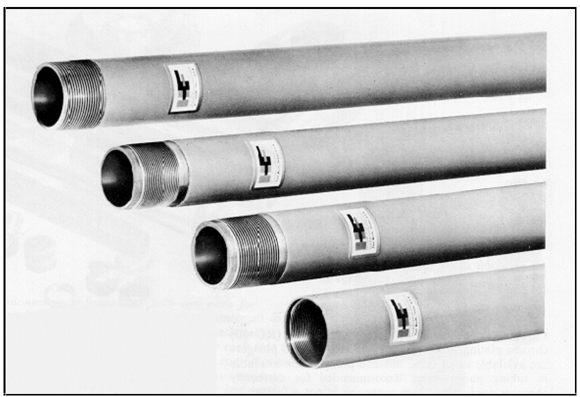

Figure 2. Examples of barrel tubes.
(courtesy of Harbison Fischer)

Plunger. The plunger moves the fluid from the bottom of the pump to the top of the pump. This movement may be a result of the plunger moving within the barrel or due to the barrel moving around the plunger. Plungers are classified as *metallic* or *non-metallic*. Metallic plungers are available in a wide range of metal compositions and treating procedures similar those used for barrels.

Clearances between the barrel and metallic plungers are very precise. The clearances must be correct after installation in the hole with the pump temperature normalized to the bottom hole temperatures.

Barrels and plungers are also selected to resist CO_2 and H_2S corrosion. The plunger may also be grooved or non-grooved according to well conditions.

The non-metallic plungers or *soft-pack* plungers come in various designs of cups and rings. Ring designs may be referred to as regular flexite, wide flexite, composition ring, soft-packed, and other terms. The soft-pack cup composition and method of assembly is selected based on well conditions such as poor lubrication, fluids with high corrosive or abrasive properties, temperature, and fluid gravity.

Figure 3. Examples of plungers.
(courtesy of Harbison Fischer)

Traveling valve. The traveling valve is at the top of the pump. Like the standing valve, it is a one-way valve. It allows oil to flow out of the barrel and keeps the fluid from flowing back into the barrel. Although the standing valve and traveling valve are separate parts, for a given pump, these two valves may be the same size, have the same composition, and be interchangeable. Consequently, the construction and operation are the same as that described above with regard to standing valves.

Holddown seal assembly. The holddown seal assembly or simply *holddown* creates a seal between the pump and the tubing. There are three types of holddown assemblies: two mechanical and one cup type. These three styles are shown in Figure 3. Each must be installed with an appropriate seating nipple in the tubing string. The seating nipples for the cup-type assembly are available in two lengths. The short model provides one seating area, while the longer model is reversible and can be turned around in the tubing to provide a new seating area if the other has been damaged.

Both mechanical and cup styles of holddowns are satisfactory for many installations, but if the bottom hole temperature is 250° F. or greater, a mechanical holddown should be used.

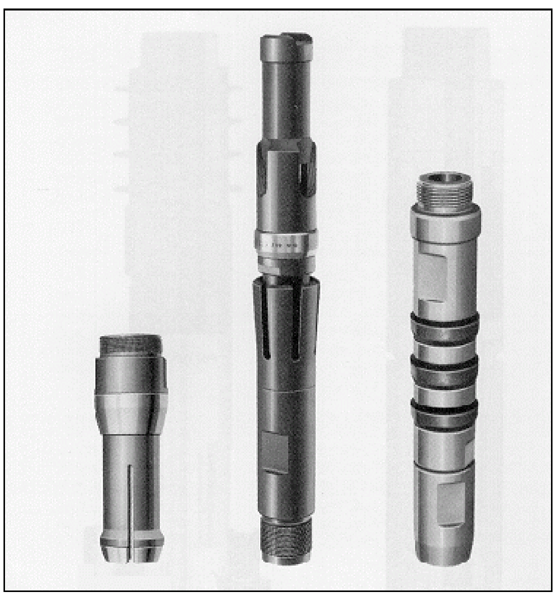

Figure 4. Holddown seal assemblies. The two on the left are mechanical types while the one on the right is a cup type.
(courtesy of Trico Industries, Inc.)

D-2. Pumps Designs.

There are four basic downhole pump designs, including three styles of insert pumps and one tubing pump (Figure 5).

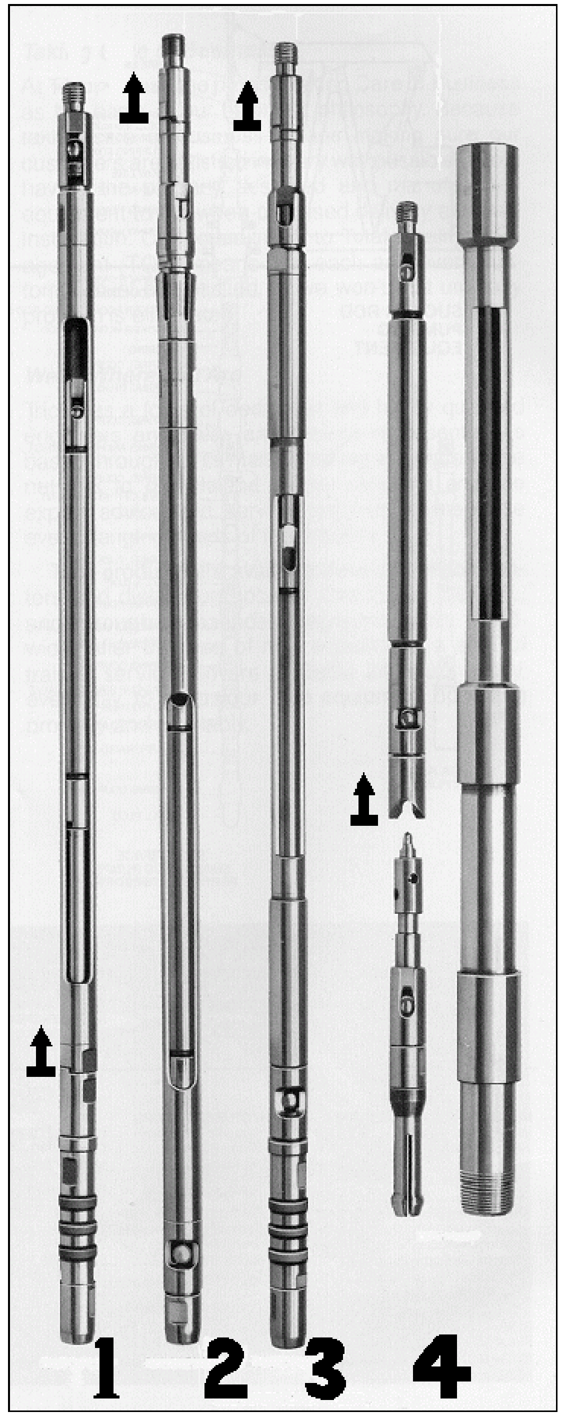

Figure 5. Four styles of downhole pumps.
(courtesy of Trico Industries, Inc.)

Insert pumps. The term *insert* indicates that the pump has been assembled as a complete functional pump and inserted into the tubing string. An insert pump may have a moving or a stationary barrel and it may be anchored at the top or the bottom. Thus, the three styles of insert pumps include designs with:

- Traveling barrel, bottom anchor.
- Stationary barrel, top anchor.
- Stationary barrel, bottom anchor.

- **Traveling barrel, bottom anchor insert pump.** The traveling barrel is very versatile. It will operate in normal wells, sandy wells, and corrosive wells with good results. With each stroke, it surges the fluids around the bottom of the pump which reduces the possibility of sand sticking the pump in the hole. The open-style valve cages provide less restriction when pumping heavy crude oils. The traveling barrel has a greater resistance against bursting, especially when a heavy barrel is used. One of the disadvantages of this pump design is that it will gas lock easier than the models with the stationary barrel because the standing valve is smaller than the traveling barrel. It is less efficient in crooked holes because the outside of the barrel wears during operation; therefore, a guide above the pump may be necessary.
- **Stationary barrel, top anchor insert pump.** With this pump, the holddown is at the top of the pump, so most of the pump hangs below the seating nipple and tubing perforations. This is a good configuration with sandy wells because of the swirling action of the fluids around the top of the pump while it is in operation. The pressure inside the pump barrel is much greater than the casing pressure outside the pump. This is because the inside must withstand the pressure generated by the column of fluid. This limits the depth at which the pump can be safely run. Gas pounding can also cause the barrel to split. With shallow (less than 5,000 feet in depth), sandy wells, this pump design can give good performance.
- **Stationary barrel, bottom anchor insert pump.** The stationary barrel, bottom anchor pump is subject to corrosion and sanding conditions on the outside of the barrel, but this is generally the most satisfactory of all of the insert pumps. Because of its design, the standing valve can be larger than the traveling valve. The column of fluid inside the tubing supports the outside of the pump barrel at all times. This reduction in differential pressure results in longer pump life and improved efficiency. This pump is used in shallow to very deep wells. Sand settling around the barrel and scale can make it difficult to pull the pump. This can generally be solved by *stripping the well*—that is, pulling the rods and tubing at the same time; also referred to as a *stripper job*.

Tubing pumps. The tubing pump is different from the insert pump because the barrel of the pump is run in the hole as part of the tubing string. Usually the standing valve and the traveling valve are run in on the rod string. After the standing valve is lowered to the bottom of the hole, the rods turn to release it. The rods are then positioned up a few inches, and the pump is ready to begin pumping. The standing valve can be reattached for pulling, servicing, and re-running when pulling rods.

An up-arrow has been added to Figure 5 to indicate the location of the clutch and also where the pump separates to allow it to pump. The part above this arrow is the action section. It moves up and down with each stroke of the pump and contains the traveling valve and plunger. The section below this arrow is the stationary section of the pump and contains the standing valve.

There are obvious advantages to running a tubing pump, such as pumping large volumes in water flood projects. One of the disadvantages is the necessity of pulling the tubing string to service the pump barrel The second disadvantage is the high fluid load on the rod string. This results in additional rod stretch and loss of bottom hole stroke.

Other styles of pumps. Other designs of downhole pumps exist. Some are just variations of those described, while others meet the needs of specific installations. The assistance of a pump manufacturer is invaluable when planning pump installations, especially for special needs.

Appendices A-1 and A-2 provide additional information about API number designations.