

SLEEVE TYPE BEARINGS AND THEIR LUBRICATION SYSTEMS IN VERTICAL TURBINE PUMPS, MIXED FLOW, AND AXIAL FLOW PUMPS

by
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ABSTRACT

Shafting and different sleeve type bearing systems, and the associated lubrication arrangements to support these systems in vertical diffuser type pumps, are discussed.

INTRODUCTION

In general, vertical diffuser type pumps are built with shafting and sleeve type bearings that need lubrication, either by the pumped fluid, or in cases when the pumped fluid is not satisfactory, by a lubricant from outside sources.

There are a great number of variations available for both the bearing design and nonprocess lubrication systems for vertical pumps. The service for which the pump is intended and the degree to which the process can accept lubrication contamination dictates, to a large degree, the proper design of these systems.

This discussion includes oil lubrication, product lubrication, water flushing, and grease lubrication. It mentions a few of the more common bearing and shafting combinations, and also shaft hardfacings and bearing hardfacings.

BASIC CONSTRUCTION AND LUBRICATION SYSTEMS

The basic lineshaft deepwell turbine pump comes in two varieties:

- Oil lubricated
- Water lubricated

Oil Lubricated

The oil lubricated pump, as shown in Figure 1, has a drip-feed oil lubrication system, where the oil is gravity-fed to the bronze

lineshaft bearings. These bearings are inside a shaft enclosing tube, with the threaded bearings also acting as tubing connectors. This enclosing tube protects the lineshaft bearings from the pumped water and allows startup of the pump, regardless where the water table is, as long as it is above the bowl assembly. The oil is fed into the annular space between the shaft and tube, and flows down to each successive bearing. The lineshaft bearings have one or two spiral grooves to help pump the oil down. The grooves are normally about 1/8 in wide and 1/16 in deep. Without the spiral pump down groove oil will not flow down the shaft fast enough to lubricate all the bearings, as the clearance between shaft and bearing is very small (say, approximately .010 in for a 1 1/2 in shaft and bearing assembly).

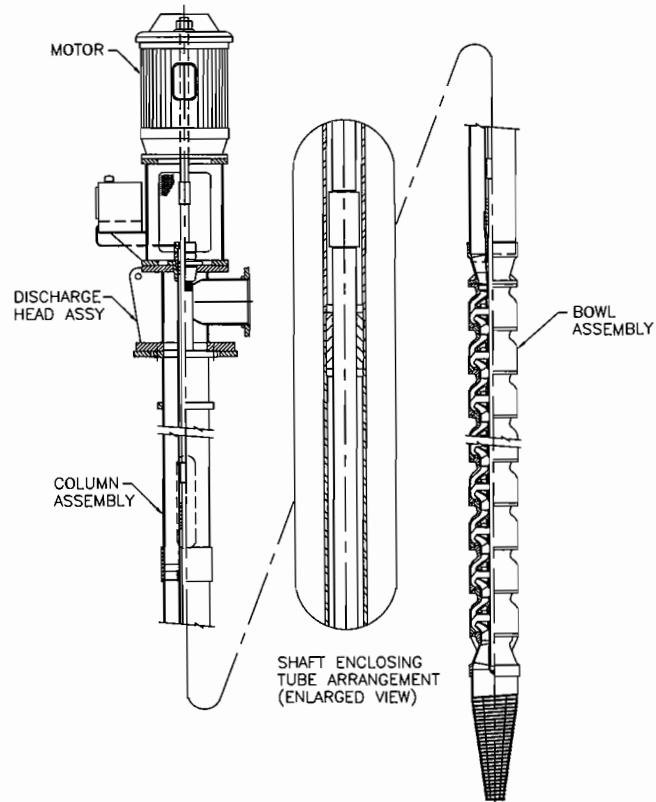


Figure 1. Oil Lubricated Deepwell Turbine Pump.

The discharge case has bypass ports, which allows the oil at the bottom of the enclosing tube to enter the well. This also allows water to flow into the bypass ports, filling the shaft enclosing tubing until the level equalizes with the level of the well. In this case, the oil and water form an emulsion, which is also a good lubricant for the lower bearings affected. A combination bearing/throttle bushing, immediately below the bypass ports, prevents the pressurization of the shaft enclosing tube by the pumped pressure. If the combination bearing fails due to abrasive

wear, water with abrasives will enter the shaft enclosing tubing and lineshaft bearings will wear, necessitating repair (Figure 2).

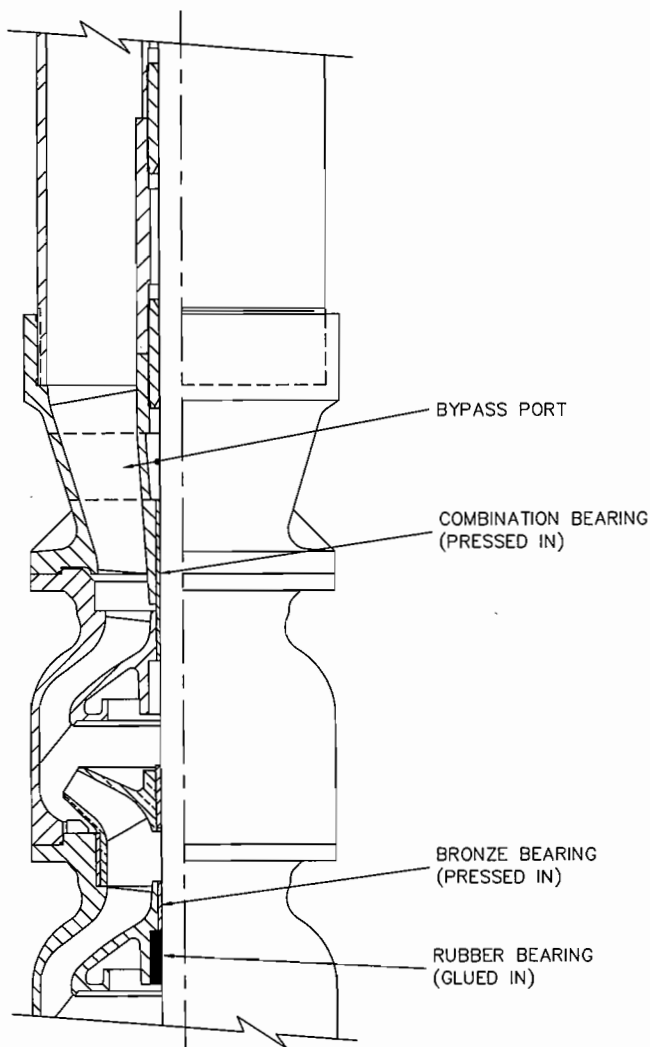


Figure 2. Standard Type Bowl Bearings and Discharge Case Bypass Port Oil Lubricated Pump.

Mineral oil is the most commonly used lubricant. However, increasingly in many areas, the normally used oil is not allowed in the aquifer, and biodegradable oils have to be used. These oils must be selected carefully; they cannot form molds or fungi, or serve as feedstock for bacteria.

The bowl assembly bearings are lubricated by the water pumped, and can be made of bronze, rubber, or various other materials. A proven and effective method is for each bowl to have a bronze and a rubber bearing (Figure 2). When the bronze bearings wear due to sand being pumped, the rubber bearings prevent the shaft from going into a critical frequency, which would destroy the bowl assembly. The bell or suction case bearing is typically grease packed.

Bronze is used simply because it makes an excellent and low cost bearing material when lubricated by oil. It will also perform well in the vertical pump when bronze bearings are lubricated by water, and in the case of light hydrocarbons, it does very well when specific gravity of the hydrocarbon exceeds .5.

Water Lubricated

The standard water lubricated, or product lubricated, open lineshaft pump is built as shown in Figure 3. These pumps are used

where oil lubrication is not desirable or permitted. All the bearings are lubricated by the water pumped. The lineshaft bearings are typically synthetic rubber, with straight or spiral flutes to allow abundant water for lubrication, and are held in bearing retainers that are clamped between each section of column pipe (Figure 4). There are numerous ways of installing bearing retainers. In threaded column pipe, they are between two column pipes inside the coupling, and they could also be pressed into flanges where flanged column pipe is used. In larger flanged column pipe, the retainers may be fabricated in the pipe. Just as in the oil lubricated construction, each bowl has a rubber and bronze bearing, and the suction case or bell uses a grease packed bearing. A packing box is used in the discharge head, to seal the pressurized pumped fluid from atmosphere. The sleeve bearing in the packing box is typically made of bronze.

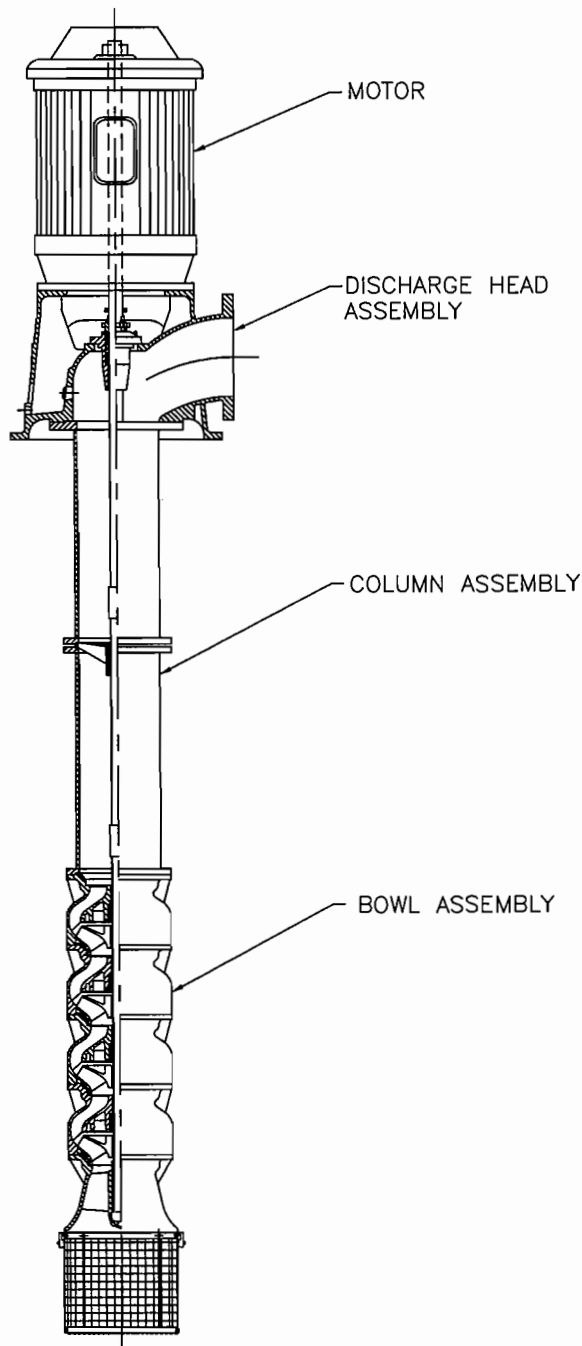


Figure 3. Water Lubricated Turbine Pump.

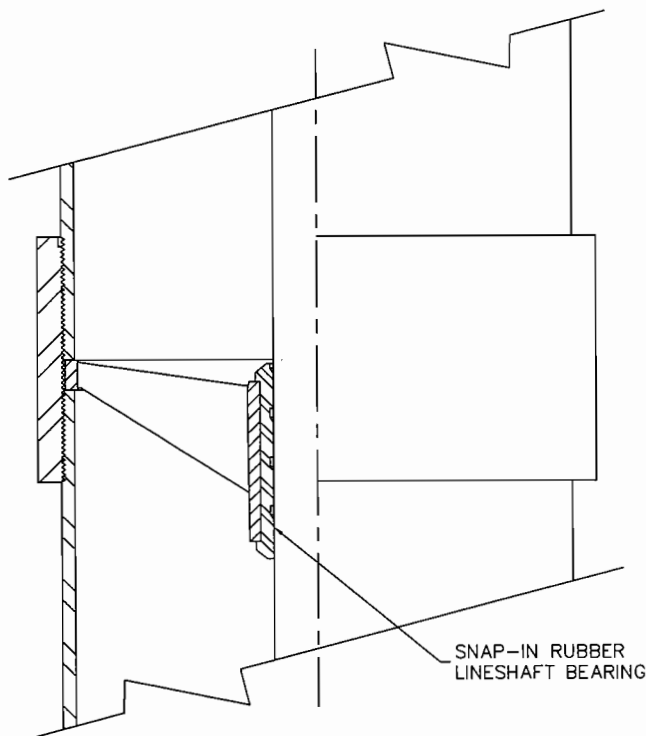


Figure 4. Example of Clamp-In Type Threaded Column Bearing Retainer—Water Lube Pump.

To work properly, rubber bearings need to be wet. Therefore, at startup, the distance to the water table is limited. In distances over approximately 50 ft, the pump lineshaft bearings need to be prelubricated, which can be achieved by using an outside source of water that is fed into the discharge head. This water will splash over all the rubber bearings to make them wet before starting the pump.

Environmental problems have arisen where bronze bearings containing lead and zinc have been banned. Therefore, bronze bearings containing extremely low percentages of lead and zinc will increasingly become the accepted material of the future.

There are numerous combinations available from the various manufacturers, concerning lubrication systems, bearing materials, and shaft materials. These variations are necessary because the vertical turbine pumps have been adapted to all kinds of services: abrasives, petrochemicals, cavern pump operations for propane, butane and other light ends, anhydrous ammonia, a variety of services in power plants, water treatment plants, steel mills, and brackish and seawater services.

Other Lubrication Systems

Following are discussions on some other lubrication systems used.

Water Flushing of Bearings

When pumps are used for highly abrasive or corrosive services, or both, pressurized water flushing will greatly extend the life of the bearings and shafting, if used properly. The lineshaft construction is similar to that of the oil lube construction, utilizing the shaft enclosing tube and standard bearings (Figure 5).

In water flush construction, the same method is used as in oil lubrication, except a packing box is incorporated in the tube tension nut assembly. This assembly mounts at the top of the enclosing tube, on the tube tension plate, and is used to keep the shaft enclosing tube in tension. The water pressure for flushing must exceed the maximum pressure developed by the pump.

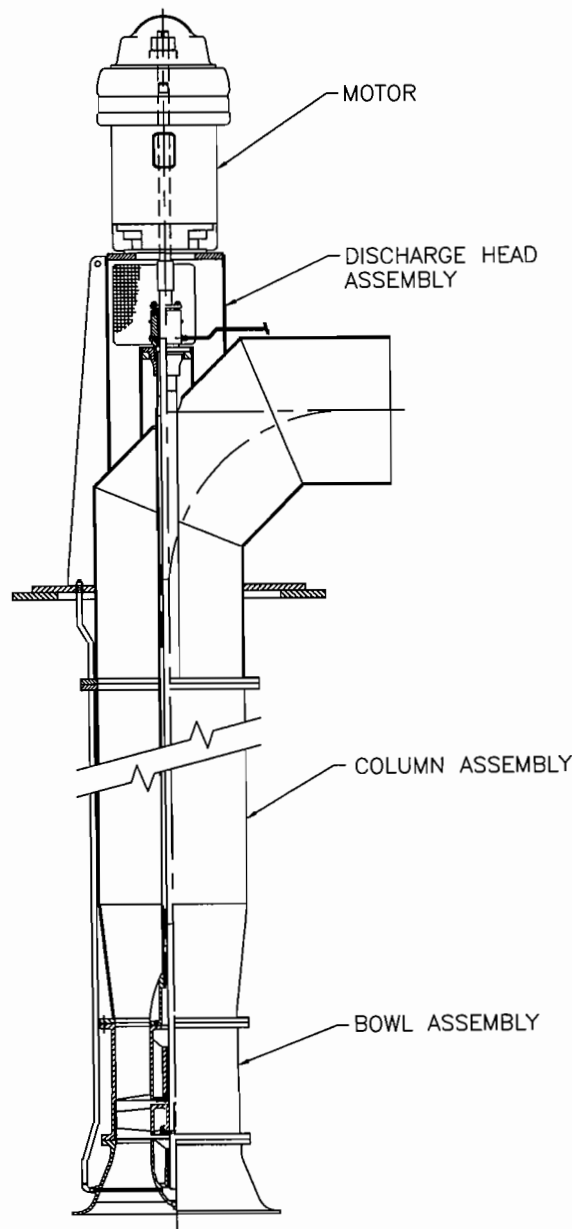


Figure 5. Axial Flow (Propeller) Pump—Waterflush Lubrication.

Normally, 15 psi over maximum pump pressure is recommended. This flush water will go down the shaft enclosing tube, and as shown in Figure 5, will lubricate all the bearings above the propeller.

Figure 5 also shows a grease line to the suction bell bearing, which is preferred on large turbine, mixed flow, or propeller pumps. When only water is used to lubricate the suction bell bearing, it is possible for a hydraulic side force acting on the impeller or propeller to cause the shaft to break through the water film in the hydrodynamic bell bearing, quickly wearing the bearing out. The grease-lubricated bearing is better able to maintain the lubricating fluid film required for suitable bearing life.

When a multistage bowl assembly is water flushed, the shaft can be rifle-drilled, and flush water continues downward to feed the intermediate bowl and suction bell bearings. Small holes drilled radially in the shaft to intersect the rifle drill, allow the flush water to lubricate and keep the bowl bearings clean. It is recommended to keep a water flush system going at all times, even when the pump is not running, to prevent intrusion of the abrasive and/or corrosive materials into the bearings.

Grease Lubrication of Bearings

This can be done in a variety of ways. Lineshaft bearings can be pressure greased through a system very similar to the water flush. Bowl bearings would need to have individual grease lines. Lineshaft bearings may also be individually greased without a shaft enclosing tube. If this method is used, a packing box is used at the discharge head (Figure 6).

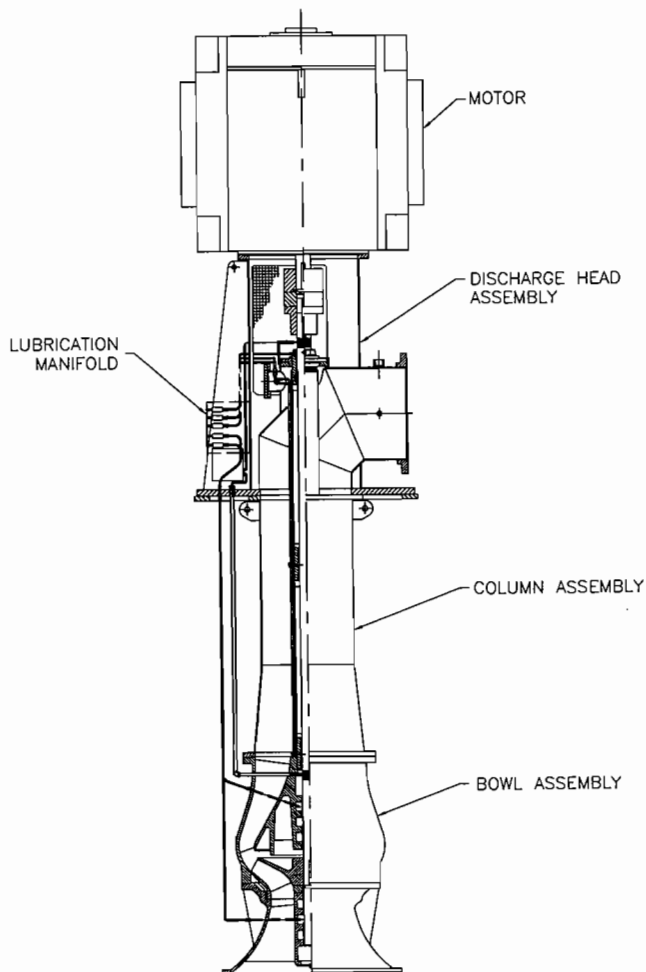


Figure 6. Large Turbine Pump, Bronze Bearings, Grease Lubricated.

Grease lines may be installed on the outside of the pump, and then enter the pump column, bowls, and suction bell. The column grease lines are well protected by steel spiders, and in the case of the bowl and suction bell, the lines are drilled through the vanes into the bearing pocket, or cast into these parts.

Sometimes grease lines to lineshaft bearings are installed internally, and attached to the shaft enclosing tube. In any case, these lines and external lines have to be well protected.

Other Ways to Handle Abrasive Water, Seawater, and Brackish Water

Abrasive fresh water may be handled quite well with rubber bearings on a hard or hardfaced shaft. The shaft or hardfacing should be of corrosion resistant material. This method is sometimes preferred over water flushing, which has the disadvantage that when it is shut off, it can be worse than no flushing system. Various composites, plastics, and elastomeric bearing materials may be used in place of rubber.

Seawater and brackish water are best handled by rubber or plastic bearings on a corrosion resistant shaft. On long setting

pumps where bronze bearings may be used, care must be taken to select zincless alloys to avoid galvanic corrosion. Often, the brackish water is more corrosive than seawater; experience will tell what is the best material to use for shafting.

Generally, in cases where rubber and other elastomers cannot be used (for instance, because of the presence of hydrocarbons), hard bearings on a hard or hardfaced shaft may be used. One successful combination is tungsten carbide coated shafting with ceramic bearings. A more economical combination would be Nitronic 60 bearings running on Nitronic 50, or type 17-4 PH stainless steel shafting.

Hard bearings are pressed into the bowls, bearing retainers, and packing box with an interference fit. Soft materials like rubber and plastics can be installed by vulcanizing or gluing them in bronze, stainless, or fiberglass sleeves, and then pressing them in. In some cases they can be glued in or they may be retained by rings or snap rings.

Bearing and Shaft Systems for Fluids Other Than Water Crude Oil

For clean crude oil, cast iron bearings can be used, and in the case of sweet crude, bronze bearings will do fine on appropriate shafting material. For sweet crude oil, carbon steel shafting is fine; for sour crude, type 316 stainless steel or better, though there are times when hardfaced steel is adequate. Any crude oil with abrasives requires a hard bearing on a hard or hardfaced shaft, which must also be corrosion resistant if the crude is sour.

Hydrocarbon Light Ends

These fluids are mostly clean, but often have marginal lubricating qualities. Various carbon, graphite, and metal filled graphite bearings will do fine. Also certain fluoropolymers such as polyetheretherketone (PEEK) have proven to be excellent performers, when reinforced with carbon or glass fibers. Shafting can typically be 416 stainless steel or carbon steel. Bronze will often do well in many cases when the specific gravity is above 0.5.

Molten Sulfur

Cast iron bearings perform well, as well as metal filled graphite. The preferred shafting is type 316 stainless steel.

Various Chemicals

There are such a great number of special chemicals that are routinely pumped using vertical pumps that it is impossible to cover them within the scope of this general treatment of the subject. These chemical services often require bearings such as metal filled graphite, and many of the composite and polymer bearing materials are also suitable for certain chemical services. The shafting material must be compatible with the bearing material and able to handle any corrosiveness or chemical attack from the pumped fluid.

Often, the user may know the best materials for use with a certain chemical, from the user's experience with valves or other equipment in the plant. It is always important to communicate this valuable information to the pump manufacturer, to assure getting the best equipment for a successful operation.

BEARING SPACING

Obviously, bearings are spaced very closely together in the bowl assemblies. However, lineshaft bearing spacing is a different matter. Like just about every piece of equipment, lineshafts have natural frequencies. These frequencies depend mainly on length between supports and diameter. This means that the pump rpm has to be different from the natural frequency.

Hard bearings are preferably spaced shorter than the first critical speed length of a particular application. On the other hand, it is quite common to space rubber bearings between the first and second critical speed length of the application.

CONCLUSIONS

Used for deepwell agricultural pumping in the past and present, vertical diffuser type pumps have been used in increasingly diverse services, due to their adaptability and versatility. Because vertical pumps have been designed, developed, and built to pump nearly any fluid, the bearing, shafting, and lubrication systems are highly critical components that must be carefully chosen, if the machinery is to perform well and provide the longest possible service life. Therefore, proper consideration must be given to design the best bearing, shafting, and lubrication system possible for a particular service.