CHAPTER 3. WELLS

(Lesson 3 of 4 Lessons)

3.4 WELL PUMPS AND SERVICE GUIDELINES

3.40 Purpose of Well Pumps

3.400 Well Pumps

Once a well is completed and water is available from an aquifer, some type of pump must be installed to lift the water from the well and deliver it to the point of use. The intent of this section is to discuss the general characteristics of well pumps operators are likely to encounter.

Well pumps are generally classified into two basic groups:

1. Positive displacement pumps, which deliver the same volume or flow of water against any *HEAD*[38] within their operating capacity. Typical types are piston (reciprocating) pumps, and screw or squeeze displacement (diaphragm) pumps.
2. Variable displacement pumps, which deliver water with the volume or flow varying inversely with the head (the greater the head, the less the volume or flow) against which they are operating. The major types are centrifugal, jet, and air-lift pumps.

Either of these types of pumps can be used for pumping water from a well. However, centrifugal pumps are by far the most commonly used pump in the waterworks field because of their capability to deliver water in large quantities, against high as well as low heads, and with high efficiencies.

3.401 Shallow Well Pump

A pump installed above a well is often called a "shallow well pump"; this pump takes water from the well by *SUCTION LIFT.*[39] Such a pump can be used for either a deep well or a shallow well providing the pumping level is within the suction lift capability of the pump (maximum of 20-feet (6-m) lift).

3.402 Deep Well Pump

A pump installed in the well with the *PUMP BOWL*[40] inlet submerged below the pumping level in the well is generally referred to as a "deep well pump." This type of pump may be used for any well, regardless of depth, where the pumping level is below the limit of suction lift.

3.41 Types of Pumps

3.410 Centrifugal Pumps

A centrifugal pump raises the water by a centrifugal force, which is created by a wheel, referred to as an "impeller," revolving inside a tight casing. In operation, the water enters the pump at the center of the impeller, called the "eye." The impeller throws the water outward toward the inside wall of the casing by the centrifugal force resulting from the revolution of the impeller. The water passes through the channel or diffuser vanes between the rim of the impeller and the casing, and emerges at the discharge under pressure. Centrifugal pumps are used almost exclusively in the waterworks field. Advantages of centrifugal pumps include: (1) relatively small space needed for any given capacity, (2) rotary rather than reciprocating motion, (3) adaptability to high-speed driving mechanisms such as electric motors and gas engines, (4) low initial cost, (5) simple mechanism, (6) simple operation and repair, and (7) safety against damage from high pressure because of limited maximum pressure that can be developed. Centrifugal pumps are generally classed as volute or turbine pumps.

3.411 Volute-Type Pumps

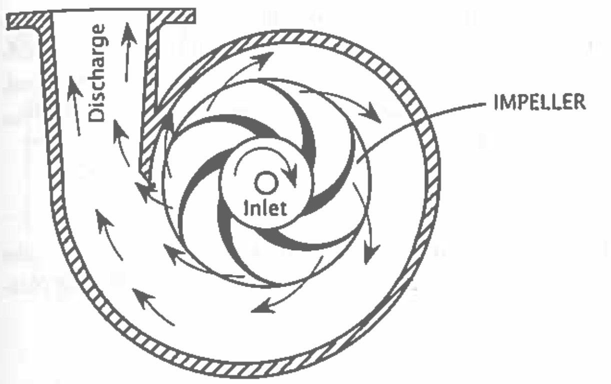
This type of centrifugal pump has no diffuser vanes (see Figure 3.17). The impeller is housed in a spiral-shaped case in which the velocity of the water is reduced upon leaving the impeller, with a resultant increase in pressure. Ordinarily, the volute-type pump is of single-stage design and used in the water utility field for large-capacity, low-head application, and for low- to mid-range booster pump operations.

3.412 Turbine-Type Pumps

This type of centrifugal pump is the one most commonly used for well pump operations (see Figure 3.18). In the turbine-type pump, the impeller is surrounded by diffuser vanes that provide gradually enlarging passages in which the velocity of the water leaving the impeller is gradually reduced, thus transforming velocity head to pressure head.

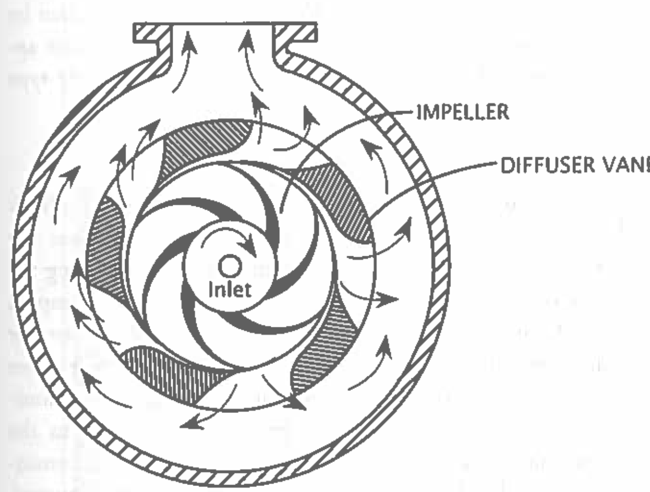
Use of multistage pumps is standard practice in well pumping operations. The stages are bolted together to form a pump bowl assembly and it is not uncommon to assemble a pump bowl assembly with 10 or more stages. The function of each stage is to add pressure head capacity; the volume capacity and efficiency are almost identical for each stage. As an example, in the case of a 10-stage pump rated at 500 gallons per minute (32 liters/sec) at 250 feet (75 m) of required head, utilizing 40 *BRAKE HORSEPOWER (BHP)*[41] (30 kW), the first stage would pump 500 gallons per minute (32 liters/sec) at 25 feet (7.5 m) of head, the next stage would not increase the GPM but would add 25 feet (7.5 m) more of head; each of the remaining eight stages would also add 25 feet (7.5 m) of head making the total 250 feet (75 m) of head. The capacity would remain at 500 GPM (32 *L*/sec). However, the brake horsepower for each stage is also additive (as is head). Therefore, if each stage requires 4 BHP (3 kilowatts), then the total for the 10 stages would amount to 40 BHP (30 kilowatts).

Well pumps for water utility operation are generally of the turbine design and often are referred to as variable-displacement deep well centrifugal pumps or more simply, deep well turbine pumps.



Volute-type centrifugal pump has no diffuser vanes or guides.

Fig. 3.17 Volute-type pump
(Source: *GROUNDWATER AND WELLS*, permission of Johnson Division, UOP, St. Paul, MN)



In turbine-type pump, water leaving the impeller moves out through the curved passages between diffuser vanes.

Fig. 3.18 Turbine-type pump
(Source: *GROUNDWATER AND WELLS*, permission of Johnson Division, UOP, St. Paul, MN)

3.413 Deep Well Turbine Pumps

There are two classifications of deep well turbine pumps, depending upon the location of the prime mover (electric motor or engine).

1. Standard deep well turbine pumps are driven through a rotating shaft (lineshaft) connected to an electric motor or engine mounted on top of the well (see Figure 3.19). This type of pump requires lubrication of the lineshaft connecting the motor and the pump. Manufacturers have incorporated both oil lubrication and water lubrication into this design.
   a. In water lubricated models, the lineshaft is supported in the center of the pump column pipe by means of stainless-steel lineshaft sleeves equipped with neoprene bearings, which are lubricated by the water as it flows upward in the column pipe (see Figure 3.20).

      This type of pump is most commonly used for large capacity wells and is designed specifically for each well and for its intended function.

      Pumping capacities generally range from 200 to 2,000 gallons per minute (12.6 to 126 liters per second).
   b. Oil lubricated models have a watertight oil tube surrounding the lineshaft and oil is fed from the surface (see Figure 3.21).

   Although both oil and water lubricated pumps are used in water utility operation, oil lubricated pumps are most often used.
2. Submersible deep well turbine pumps use a pumping bowl assembly similar to the standard deep well turbine except that the motor is mounted directly beneath the bowl assembly. This eliminates the need for the lineshaft and oil tube (see Figure 3.22). Unit efficiency approaches that of a lineshaft turbine pump.

Submersible pumps are available in a wide range of capacities from 5 to 2,000 gallons per minute (0.3 to 126 liters/sec), and are used by individual well owners as well as by small and large water system operators.

[38] *Head.* The vertical distance, height, or energy of water above a reference point. A head of water may be measured in either height (feet or meters) or pressure (pounds per square inch or kilograms per square centimeter). Also see DISCHARGE HEAD, DYNAMIC HEAD, STATIC HEAD, SUCTION HEAD, SUCTION LIFT, and VELOCITY HEAD.

[39] *Suction Lift.* The negative pressure [in feet (meters) of water or inches (centimeters) of mercury vacuum] on the suction side of a pump. The pressure can be measured from the centerline of the pump down to (lift) the elevation of the hydraulic grade line on the suction side of the pump.

[40] *Pump Bowl.* The submerged pumping unit in a well, including the shaft, impellers, and housing.

[41] *Brake Horsepower (BHP).* (1) The horsepower required at the top or end of a pump shaft (input to a pump). (2) The energy provided by a motor or other power source.

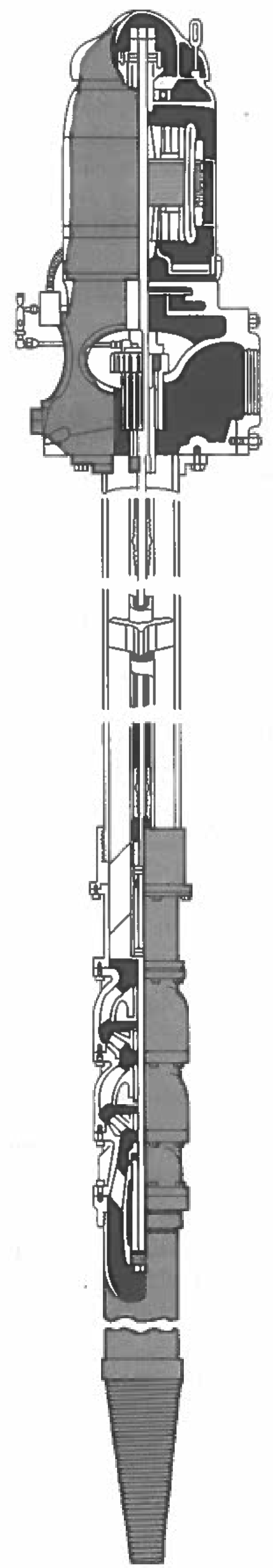


Fig. 3.19 Standard deep well turbine pump
(Permission of Jacuzzi Brothers, Inc.)

Submersible pumps are ideally suited to small water system operation where source capacities range from 25 to 1,000 gallons per minute (1.5 to 63 liters/sec). Maintenance is minimal, the noise level is very low, and they are suited to installations that have limited building areas.

3.414 Other Pumps

There are numerous types of pumps that may be used in the water utility field such as those discussed in the following paragraphs.

1. JET PUMPS (Figure 3.23)

   These were used for years on individual wells prior to the development of submersible pumps. They are low in efficiency and are generally restricted to lifts of 100 feet (30 m) or less.

2. PISTON PUMPS (Figure 3.24)

   All piston pumps function by means of a piston movement that displaces water in a cylinder. The flow is controlled by valves. They are restricted to low-capacity, high-pressure applications and are being phased out in favor of turbine-type pumps.

3. ROTARY PUMPS (Figure 3.25)

   The rotary pump uses cogs or gears, rigid vanes, and flexible vanes. When rotated, a gear-type pump squeezes the water from between the close-fitting gear teeth, moving the water from the inlet side to the outlet side of the pump. A typical rigid-vane rotary pump has a series of dividers or vanes fitted into a slotted rotor. When rotated, these vanes move radially to conform to the contour of the pump housing. The pump housing is eccentric with relation to the rotor, so that the water is pushed from the pump in a continuous flow ahead of the vanes. In flexible-vane rotary pumps, the vanes are elastic blades (usually rubber), which bend to provide the change in displacement volume that forces the water along its path. Rotary pumps are usually used for booster purposes and are generally used in conjunction with another pump.

The above-mentioned pumps have a very limited application and are discussed in this section for the purpose of familiarizing operators with pumps that could be found in water utility operations.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 139.

3.4A What are the two basic groups of well pumps and the differences between them?

3.4B List as many advantages of a centrifugal pump as you can recall.

3.4C Why is the installation of jet pumps not too common today?

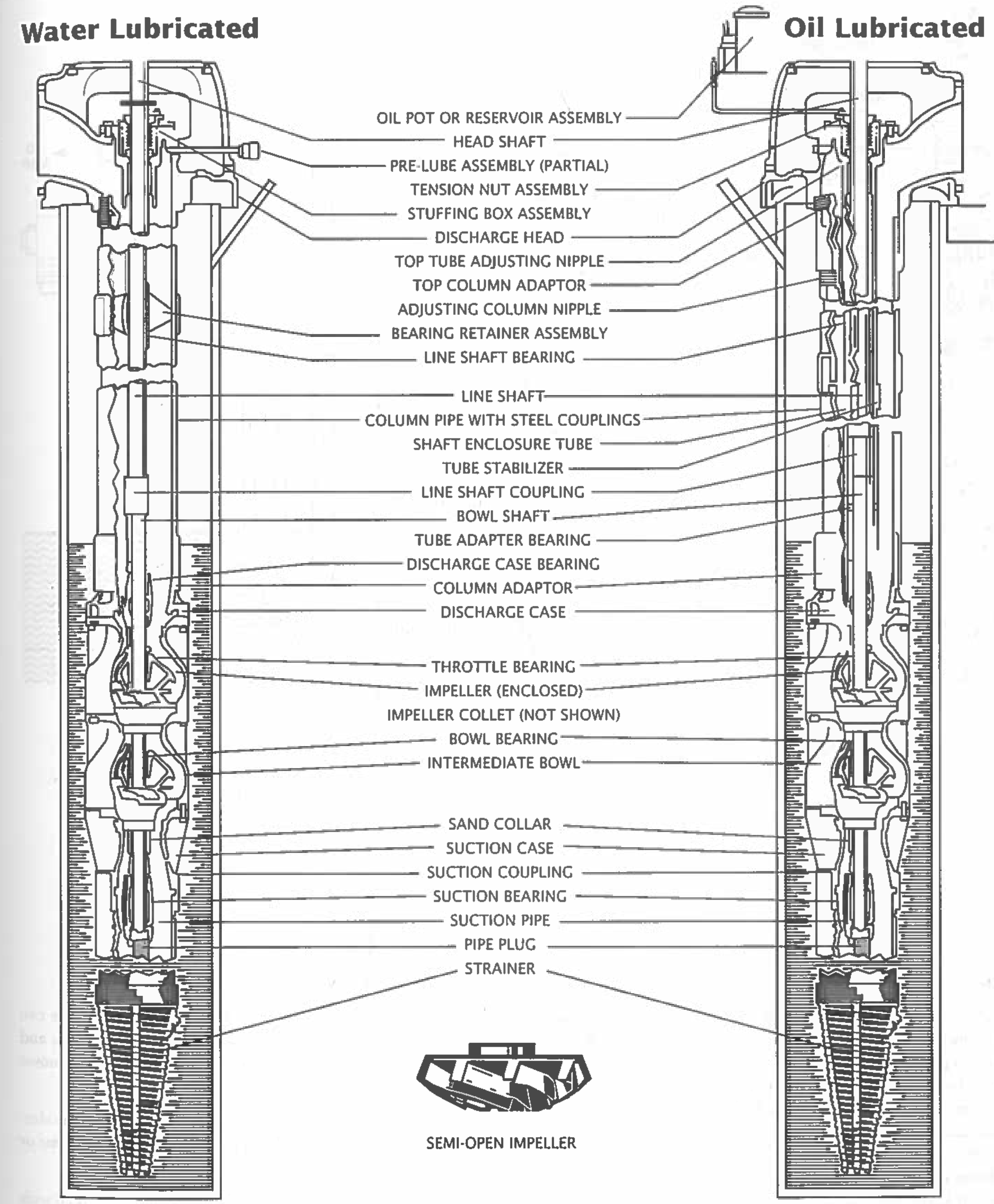


Fig. 3.20 Water lubricated pump

Fig. 3.21 Oil lubricated pump

(Adapted from Peabody Floway, Inc., Fresno, CA)

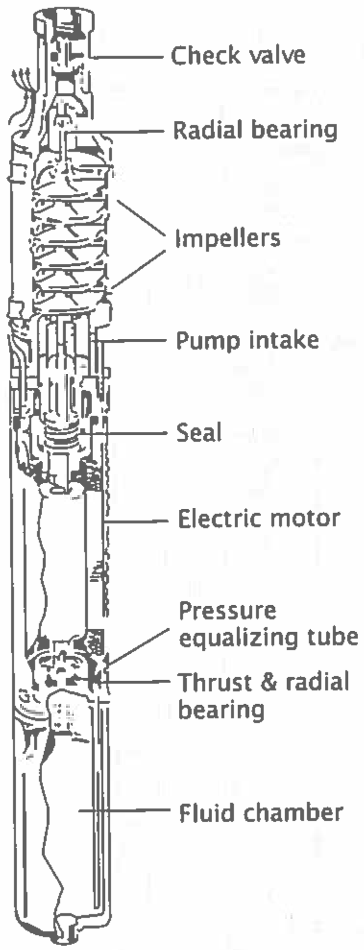
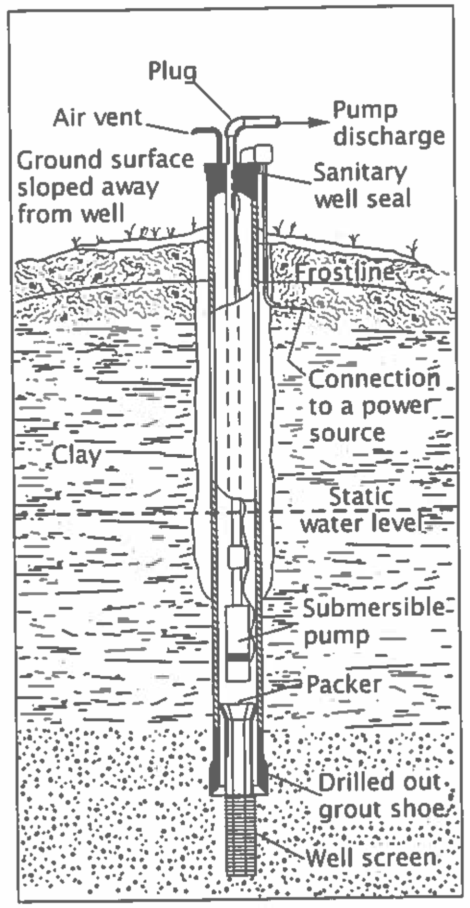


Fig. 3.22 Submersible pump
(Source: *GROUNDWATER AND WELLS*, permission of Johnson Division, UOP, St. Paul, MN)



This well has been vented and sealed properly. The groundwater surface around the top of the casing has been graded to slope away in all directions. *(After US Environmental Protection Agency, 1973)*

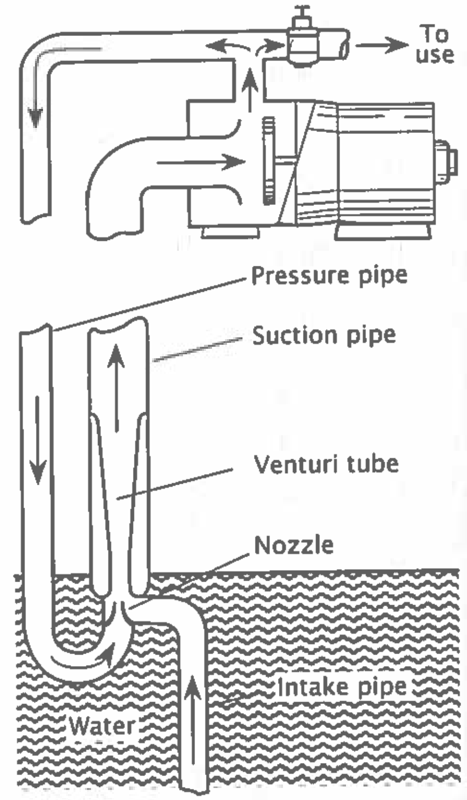


Fig. 3.23 Typical jet pump
(Source: *GROUNDWATER AND WELLS*, permission of Johnson Division, UOP, St. Paul, MN)

3.42 Column Pipe

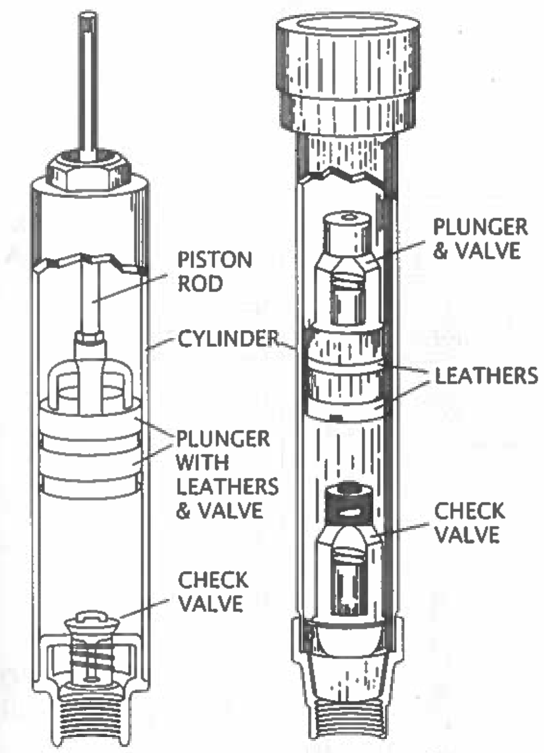
Operators should be aware of the functions of the pump column pipe in a deep well turbine pumping installation. The column pipe is an integral part of the pump assembly and serves three basic purposes: (1) the column pipe connects to the bottom of the surface discharge head, extends down into the well, and connects to the top of the well pump (bowl unit) thereby supporting the pump in the well, (2) the column pipe delivers water under pressure from the well pump to the surface, and (3) keeps the lineshaft and shaft enclosing (oil) tube assembly in straight alignment. Column pipe assemblies for both water and oil lubricated pumps are shown in Figures 3.26 and 3.27.

3.43 Right-Angle Gear Drives (Figures 3.28 and 3.29)

Right-angle gear drives for water utility operations have two distinct applications and provide an economical, efficient, and positive power transmission from a horizontal prime mover (electric motor or engine) to a vertical shaft.

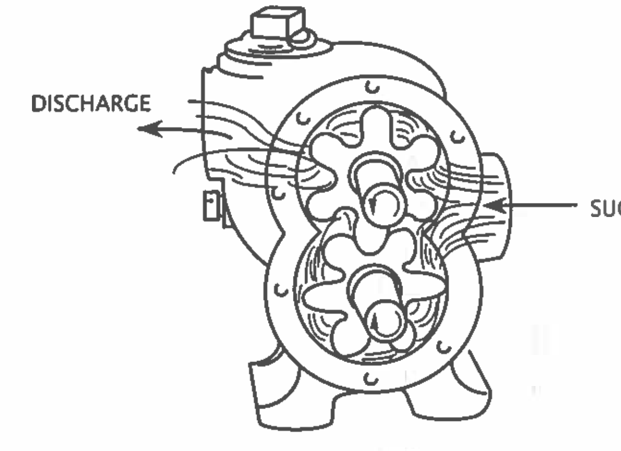
In one application, the right-angle gear drive replaces the electric motor on top of the well and is used on either a full-time or part-time basis.

In a second application, the right-angle gear drive is used with the electric motor. The gear drive is mounted on top of the well discharge head and the electric motor is connected to the right-angle gear drive. An extra long headshaft (an extension of the

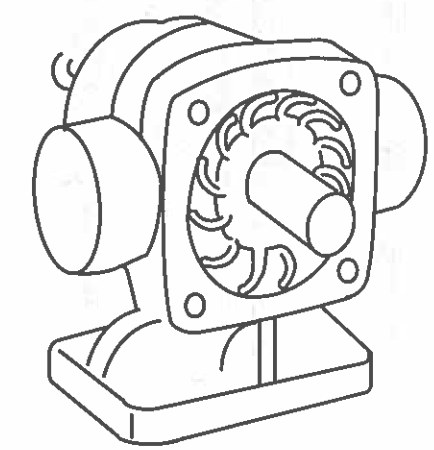


NOTE: Leathers are O-rings or gaskets used to provide a seal between the piston and the side wall.

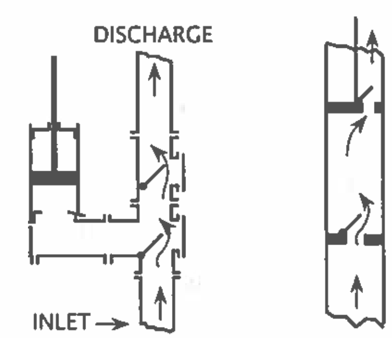
(Source: *GROUNDWATER AND WELLS*, permission of Johnson Division, UOP, St. Paul, MN)



ROTARY GEAR PUMP



(Source: *GROUNDWATER AND WELLS*, permission of Johnson Division, UOP, St. Paul, MN)



SINGLE-ACTING PISTON PUMPS

Fig. 3.24 Typical piston pumps
(Reprinted from *WATER SUPPLY ENGINEERING* by Babbit, Dolan, and Cleasby, Sixth Edition, by permission. Copyright 1962, McGraw-Hill Book Company)

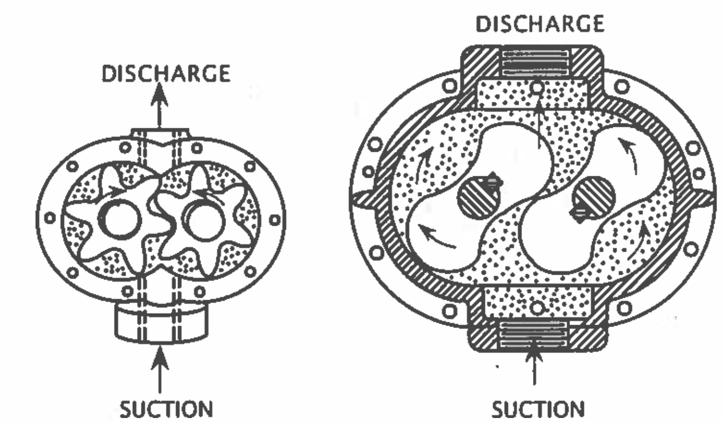
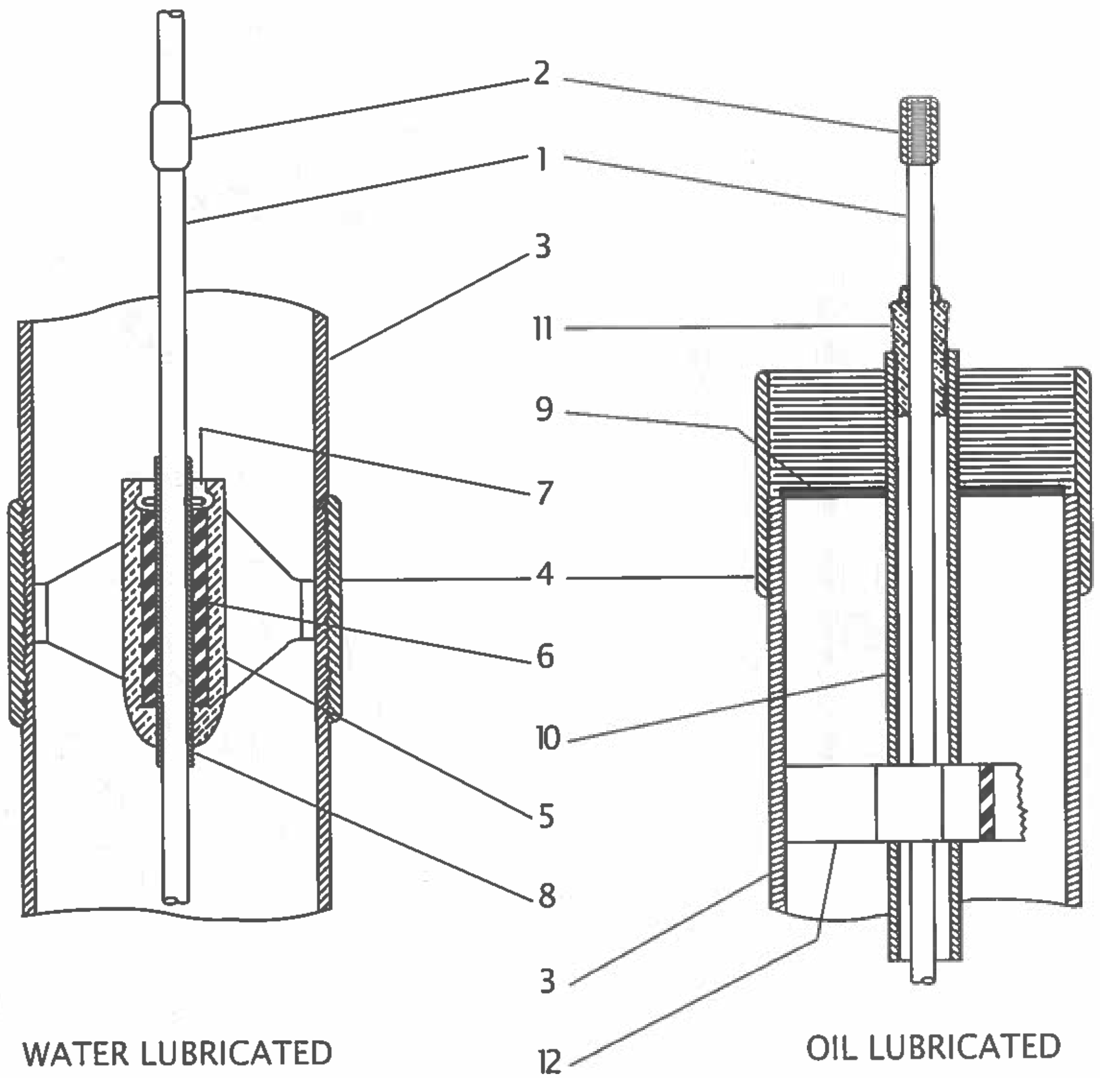


Fig. 3.25 Rotary pumps
(Reprinted from *WATER SUPPLY ENGINEERING* by Babbit, Dolan, and Cleasby, Sixth Edition, by permission. Copyright 1962, McGraw-Hill Book Company)



1 LINE SHAFT
2 SHAFT COUPLING
3 COLUMN PIPE
4 COLUMN PIPE COUPLING
5 BEARING CAGE
6 RUBBER SHAFT BEARING

7 SNAP RING
8 SHAFT SLEEVE
9 COLUMN PIPE SPACER RING (OPTIONAL)
10 OIL TUBE
11 LINE SHAFT BEARING
12 TUBE STABILIZER

Fig. 3.26 Column pipe assembly for water lubricated pumps

Fig. 3.27 Column pipe assembly for oil lubricated pumps

(Permission of Peabody Floway, Inc., Fresno, CA)

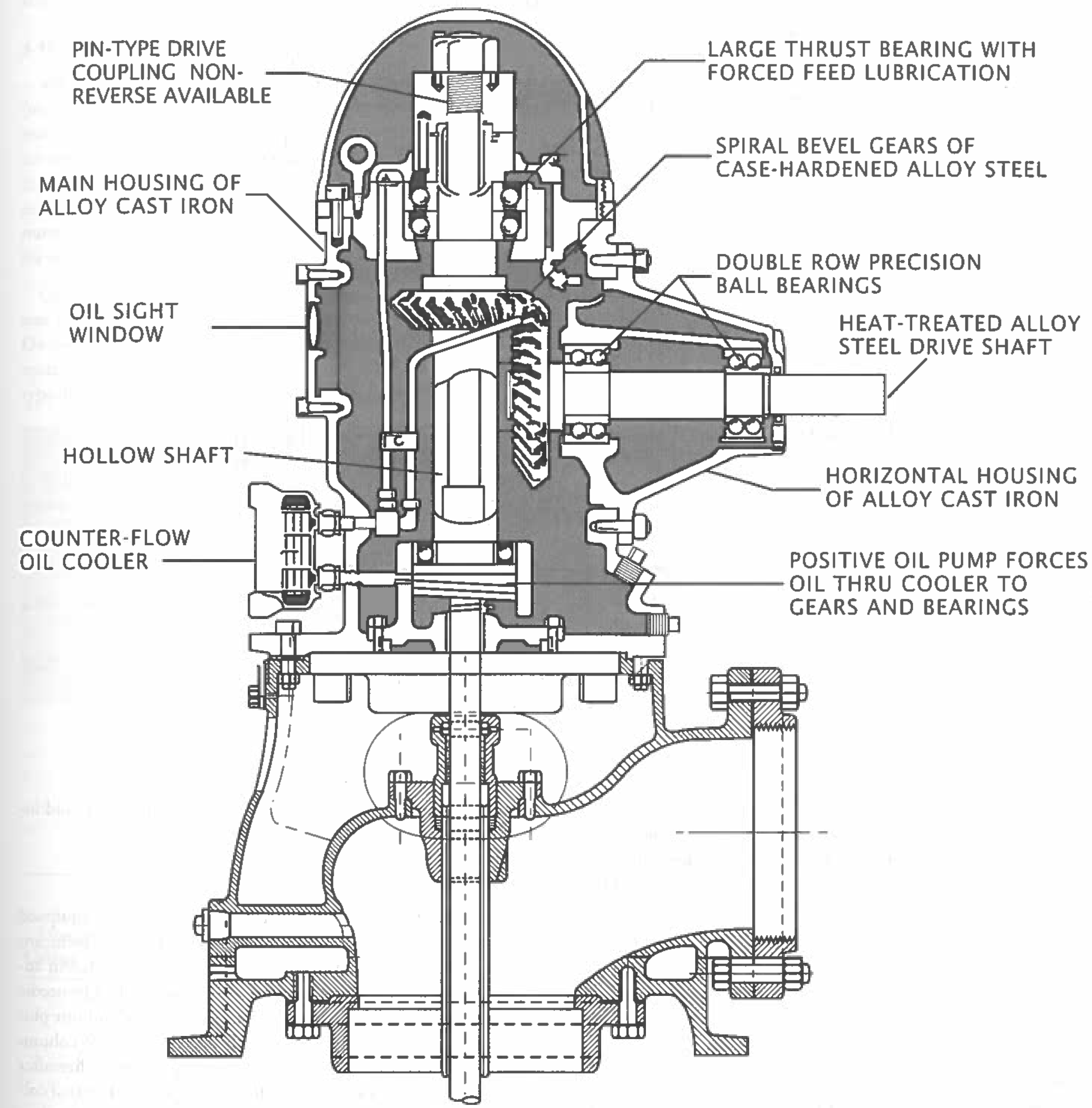


Fig. 3.28 Right-angle gear drive

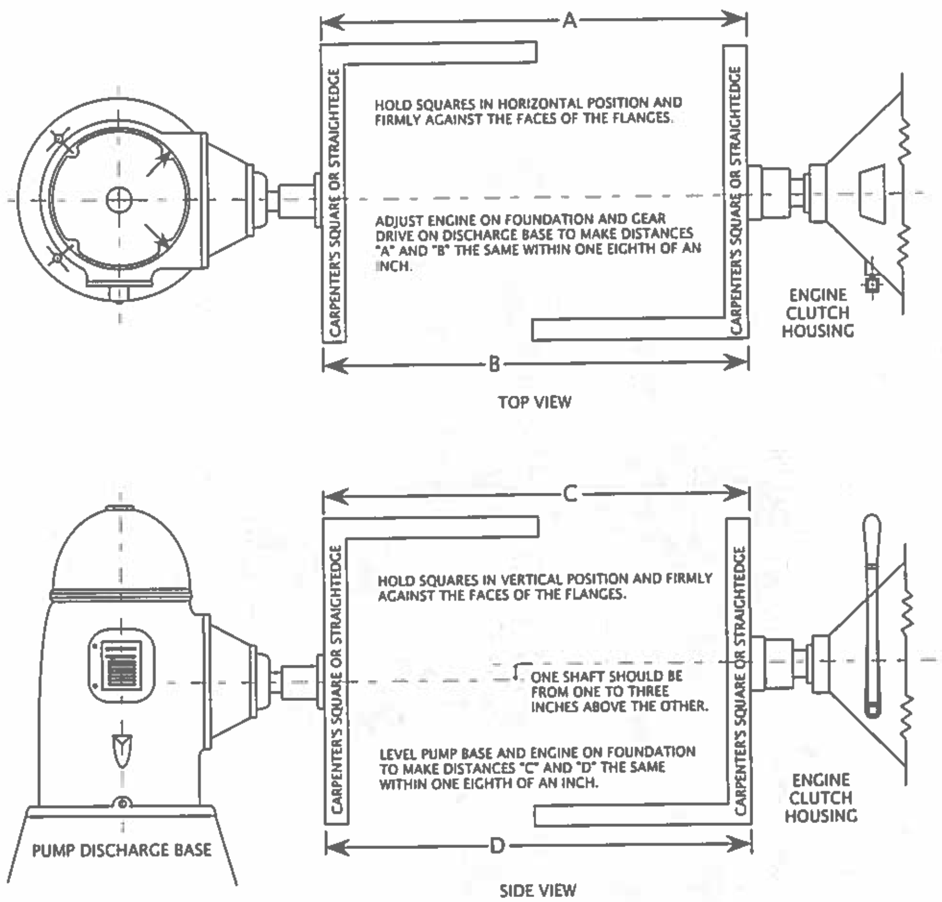


Fig. 3.29 Alignment of right-angle gear drive
(Source: Amarillo Right Angle Pump Drive, Amarillo, TX)

lineshaft) connects both prime movers to the bowl unit in the well. In most applications, the electric motor is the lead prime mover and the right-angle gear drive unit is used for standby or emergency purposes only. The unit is usually set up for automatic operation.

In either application, the prime mover could be in the form of a gasoline, natural gas, diesel, or propane-powered engine connected to the gear head by means of a flexible drive shaft.

3.44 Selecting a Pump

Before an appropriate pump can be selected for any installation, accurate information about required capacity, location and operating conditions, and total head is needed. With this data available, the selection of the type, class, and size of a pump can be made.

After the best type of pump has been determined on the basis of available data, an individual pump must be selected that will best fit each situation. This selection is particularly important if a well is the source of water supply and must take into account differences in pumping head caused by seasonal variations of the static water level, temporary lowering of the pumping water level as a result of long periods of continuous pumping, and interference from other wells in the area.

3.45 Service Guidelines

Deep well turbine, oil lubricated pumps are usually equipped with an automatic electric oiler system that is activated by means of an electric solenoid valve when the well pump starts. An adjusting needle and sight glass are part of this assembly. The needle valve is adjusted to feed approximately five drops per minute plus one drop of oil per minute for each 20 feet (6 m) of column during the first week of operation. The drip rate may thereafter be reduced to one drop per minute for each 40 feet (12 m) of column. Under no circumstances should the drip rate be less than five drops per minute, regardless of the length of column.

A good grade of turbine oil (mineral base) SAE 10 is used as the lubricant. Automotive or diesel engine lubricating oils cannot be used as a lineshaft lubricant. To obtain the best lubrication oils for lineshaft bearings, consult with the manufacturer and your lubrication sales representative.

Deep well turbine, water lubricated pumps are self-lubricating and normally require little or no lineshaft maintenance. In a few

cases, where the static water level is over 100 feet (30 m) and the pump is operated on an intermittent basis, a special small-diameter, pressurized water line may be used to keep the bearings above the water level lubricated.

3.46 Motors

Vertical, hollow-shaft motors for deep well turbine pumps (motor on top of well) require some degree of routine maintenance. The motor bearings at the top and bottom of the motor are enclosed within a weatherproof oil bath container. The oil in this container should be changed annually. Most motors are equipped with a lubrication instruction plate attached to the motor that specifies the proper type and viscosity of oil required for various operating temperatures.

On small motors, the bearings are generally grease lubricated and require weekly attention during the heavy pumping season. Do not use excess grease because the bearings will overheat. The motor manufacturer's instruction manual should specify the type of grease recommended for various applications.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on pages 139 and 140.

3.4D List the three basic purposes of the pump column pipe in a deep well turbine pumping installation.

3.4E What are the prime movers used with right-angle gear drives?

3.4F How are deep well turbine, oil lubricated pumps lubricated?

3.5 DISINFECTION OF WELLS AND PUMPS

(Also see Chapter 5, "Disinfection.")

3.50 New Wells—During Construction

During the drilling of new wells, contamination could be introduced into the well from the drilling tools and mud, makeup water, topsoil falling in or sticking to tools, and from the gravel itself.

The procedure described below is generally satisfactory for disinfecting a well; however, other methods may be used provided it can be demonstrated that they will produce comparable results. Disinfection should take place following development, testing for yield, and before the test pump is removed from the well. This will ensure that the well is purged of drilling mud, dirt, and other debris that reduces the effectiveness of the disinfecting solution.

1. Add to the well a chlorine solution strong enough to produce a chlorine concentration of 50 mg/*L* in the well casing. Table 3.8 lists quantities of various chlorine compounds required to dose 100 feet (30 meters) of water-filled casing at 50 mg/*L* for diameters ranging from 6 to 24 inches (150 to 600 mm). Organic matter such as oil may need an initial concentration of 1,000 mg/*L* before being injected into the well. This is 20 times the values in Table 3.8.

2. Turn the pump on and off several times so as to thoroughly mix the disinfectant with the water in the well. Pump until the water discharged has the odor of chlorine. Repeat this procedure several times at one-hour intervals.

3. Allow the well to stand without pumping for 24 hours.

TABLE 3.8 CHLORINE COMPOUNDS REQUIRED TO DOSE 100 FEET[a] OF WATER-FILLED CASING AT 50 MILLIGRAMS PER LITER[b]

	Chlorine Compounds		
Diameter of Casing (Inches)	Calcium Hypochlorite (65%), Sold as HTH or Perchloron (Dry Weight)[c, d]	Chloride of Lime (25%) (Dry Weight)[c, d]	Sodium Hypochlorite (5.25%), Sold as Purex or Clorox (Liquid Measure)[e]
6	2 ounces	4 ounces	20 ounces
8	3 ounces	7 ounces	2⅛ pints
10	4 ounces	11 ounces	3½ pints
12	6 ounces	1 pound	5 pints
16	11 ounces	1¾ pounds	1 gallon
20	1 pound	3 pounds	1⅔ gallons
24	1½ pounds	4 pounds	2⅔ gallons

[a] *WATER WELL STANDARDS,* Bulletin 74, California Department of Water Resources, Sacramento, CA.
[b] Some authorities recommend a minimum concentration of 100 mg/*L*. To obtain this concentration, double the amounts shown.
[c] Where a dry chemical is used, it should be mixed with water to form a chlorine solution prior to placing it into the well. HTH stands for High Test Hypochlorite, which is calcium hypochlorite or $Ca(OCl)_2$.
[d] 16 ounces = 1 pound (Dry Weight)
[e] 16 fluid ounces = 1 pint; 2 pints = 1 quart; 4 quarts = 1 gallon

4. The water should then be pumped to waste until the odor of chlorine is no longer detectable. Use a chlorine test kit to determine the absence of a chlorine residual.
5. Collect a bacteriological sample in a sterile container and submit it to a laboratory for examination.
6. If the laboratory analysis shows the water is not free of bacterial contamination, repeat the disinfection procedure and retest the water. If repeated attempts to disinfect the well are unsuccessful, a detailed investigation to determine the cause or source of the contamination should be undertaken.

3.51 New Wells—After Construction

Prior to placing a new well pumping installation in service, the well disinfection procedure previously described should be repeated. This will protect against contamination caused during the construction of the pump base and related appurtenances, and the installation of the permanent pumping unit.

3.52 Existing Wells—After Well or Pump Repairs

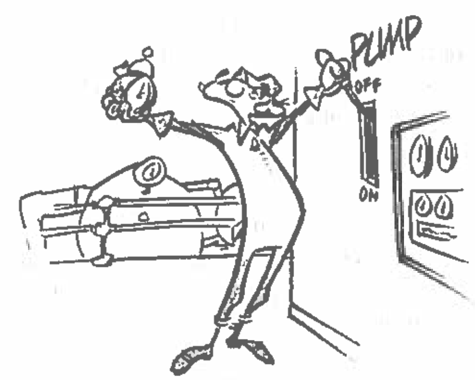
Disinfection of existing wells following repairs to the well or replacement of pumping equipment may require special disinfection methods. During the repair work, deposits of slime, bacterial growth, and other debris are dislodged from the inside surfaces of the well casing and from the outside surfaces of the well pump column pipe. These deposits generally settle to the bottom of the well, but some are also smeared on the inside surfaces of the well casing, particularly above the waterline. Those deposits above the waterline are difficult to disinfect by typical well disinfection procedures. The following special procedures are recommended.

1. Swab inside of well casing with a strong nonfoaming detergent such as trisodium phosphate or Calgon.
2. Calculate amount of chlorine based on diameter of well and water depth. The chlorine dosage rate should produce a free chlorine concentration of at least 100 mg/*L* in the water-filled casing.
3. Add chlorine solution to the well, preferably through a hose raised and lowered to reach all areas of the well, including the well casing above the waterline.
4. Clean and disinfect pump, pump column pipe, cable, and other equipment before the units are lowered into the well.
5. Follow procedures 2 through 6 for new well disinfection (Section 3.50).

3.53 Contaminated Wells

If the well and pumping unit must be disinfected because of contamination or bacterial problems and the well pump is left in place, then follow these special methods:

1. To the well* add a chlorine solution, strong enough that it produces a chlorine concentration of 200 mg/*L* in the well casing. (* See Sections A and B below for procedures on how to add the chlorine solution to the well.)



2. Turn the pump on and off several times to thoroughly mix the disinfectant with the water in the well. Pump until the water discharged has the odor of chlorine. Repeat this procedure several times at one-hour intervals.
3. Allow the well to stand without pumping for 24 hours.
4. Pump the water to waste until the odor of chlorine is no longer detectable. A chlorine test kit should be used to determine the absence of a chlorine residual.
5. Take a bacteriological sample and submit it to a laboratory for examination.
6. If the laboratory analysis shows the water is not free of bacterial contamination, repeat the disinfection procedure and retest the water. If repeated attempts to disinfect the well are unsuccessful, a detailed investigation to determine the cause or source of the contamination should be undertaken.

* A *SUBMERSIBLE PUMPS AND DEEP WELL TURBINE PUMPS—WATER LUBRICATED*

The chlorine solution should be introduced into the well through either the air release valve piping assembly (remove air release valve) or the well-casing vent, and water added to flush the chlorine solution back into the well. If the well is equipped with a foot valve, then the chlorine solution must be introduced into the well by the well-casing vent.

* B *DEEP WELL TURBINE PUMPS—OIL LUBRICATED*

Introduce the chlorine solution into the well through the air release valve piping assembly as described in (A) above. Chlorine solution or chlorine powder should not be added to the well by means of the well-casing vent. Nearly all oil lubricated pumps have a certain amount of oil floating on the surface of the water within the well casing, ranging from a thin film on the surface to slight traces of oil down to 20 feet (6 m) or more below the water surface. Chlorine, added through the well-casing vent, strikes the oil floating on the surface of the well and carries oil and debris down into the well and makes cleanup difficult. If it is absolutely necessary to apply chlorine by means of the well-casing vent, then a chlorine solution should be introduced into the well through a hose raised and lowered to reach all areas of the well below the level of the oil. If this method cannot be used, then resort to chlorine tablets. If tablets are used, allow sufficient dissolving time and follow Section 3.50, Step 2, procedure for new wells.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 140.

3.5A How could contamination be introduced during the drilling of a new well?

3.5B When should a well be disinfected?

3.5C When disinfecting a new well, what is the desired chlorine concentration in the well casing?

3.5D What would you do if repeated attempts to disinfect a well are unsuccessful?

3.5E Why does the disinfection of existing wells after well or pump repairs require special disinfection methods?

3.54 Chlorine Requirement Calculation

The amount of a chlorine compound required to disinfect a well may be determined by two different methods. The first method is the easier and uses values from Table 3.8 (page 113). The second method calculates the amount of chlorine required based on the volume of water in the casing being disinfected, the desired chlorine dose, and the amount of chlorine available in the disinfecting chlorine compound. Both methods will give the same results with the second method being slightly more accurate.

FORMULAS

Method 1

$$\text{Chlorine Required} = \frac{(\text{Table 3.8 Value})(\text{Casing Length, ft})}{100\text{ ft}}$$

To find the value in Table 3.8, you need to know:

1. Diameter of casing in inches
2. Type of chlorine compound

The length of water-filled casing in feet is used to calculate the chlorine required. Also, Table 3.8 assumes the desired chlorine dose is 50 mg/*L*. If the dose is not 50 mg/*L*, use the following formula:

$$\text{Chlorine Required (If dose not 50 mg/}L) = \frac{(\text{Chlorine Required})(\text{Desired Dose, mg/}L)}{50\text{ mg/}L}$$

Calculate the "Chlorine Required" using Table 3.8 and then adjust this answer by multiplying by the "Desired Dose, mg/*L*" and dividing by "50 mg/*L*."

Method 2

$$\text{Casing Volume, gal} = \frac{(0.785)(\text{Casing Diameter, in})^2(\text{Casing Length, ft})(7.48\text{ gal/cu ft})}{144\text{ sq in/sq ft}}$$

$$\text{Chlorine Required, gal} = \frac{(\text{Casing Volume, gal})(\text{Desired Dose, mg/}L)}{\text{Chlorine Solution, mg/}L}$$

To determine the chlorine required using Method 2 requires two steps. The first step calculates the casing volume in gallons. The second step calculates the chlorine required by multiplying the casing volume in gallons times the desired chlorine dose in mg/*L* and dividing by the chlorine concentration in the chlorine compound solution in mg/*L*. A one-percent (1%) chlorine solution is the same as a 10,000 mg/*L* chlorine solution.

EXAMPLE 1

How much sodium hypochlorite is required to dose a well at 50 mg/*L*? The casing diameter is 6 inches and the length of water-filled casing is 150 feet. Sodium hypochlorite is 5.25 percent or 52,500 mg/*L* chlorine.

Known		Unknown
Casing Diameter, in	= 6 in	Chlorine Required, gal
Casing Length, ft	= 150 ft	
Desired Dose, mg/*L*	= 50 mg/*L*	
Chlorine Solution, mg/*L* (Sodium Hypochlorite)	= 52,500 mg/*L*	

Method 1

1. Find the chlorine required from Table 3.8 for a 6-inch diameter well casing when using sodium hypochlorite.

   Table 3.8 Value = 20 ounces

2. Calculate the ounces of chlorine required.

$$\text{Chlorine Required, ounces} = \frac{(\text{Table 3.8 Value})(\text{Casing Length, ft})}{100\text{ ft}}$$

$$= \frac{(20\text{ ounces})(150\text{ ft})}{100\text{ ft}}$$

$$= 30\text{ ounces}$$

3. Convert the chlorine required from ounces to gallons of sodium hypochlorite.

$$\text{Chlorine Required, gal} = \frac{(\text{Chlorine Required, ounces})}{(16\text{ ounces/pint})(8\text{ pints/gallon})}$$

$$= \frac{30\text{ ounces}}{(16\text{ ounces/pint})(8\text{ pints/gallon})}$$

$$= 0.23\text{ gallon}$$

Method 2

1. Calculate the water-filled casing volume in gallons.

$$\text{Casing Volume, gal} = \frac{(0.785)(\text{Casing Diam, in})^2(\text{Casing Length, ft})(7.48\text{ gal/cu ft})}{144\text{ sq in/sq ft}}$$

$$= \frac{(0.785)(6\text{ in})^2(150\text{ ft})(7.48\text{ gal/cu ft})}{144\text{ sq in/sq ft}}$$

$$= 220\text{ gal}$$

2. Calculate the required gallons of sodium hypochlorite.

$$\text{Chlorine Required, gal} = \frac{(\text{Casing Volume, gal})(\text{Desired Dose, mg}/L)}{\text{Chlorine Solution, mg}/L}$$

$$= \frac{(220\text{ gal})(50\text{ mg}/L)}{52{,}500\text{ mg}/L}$$

$$= 0.21\text{ gallon}$$

NOTE: We obtained essentially the same answer by either method. Table values will tend to be slightly higher and on the safe side.

QUESTION

Work this problem in a notebook and then compare your solution with the one on page 140.

3.5F How much sodium hypochlorite is required to dose a well at 50 mg/*L*? The casing diameter is 12 inches and the length of water-filled casing is 200 feet.

End of Lesson 3 of 4 Lessons on WELLS

Please answer the discussion and review questions next.

DISCUSSION AND REVIEW QUESTIONS

Chapter 3. WELLS

(Lesson 3 of 4 Lessons)

Write the answers to these questions in your notebook. The question numbering continues from Lesson 2.

17. What is the difference between a shallow well pump and a deep well pump?
18. How does a centrifugal pump work?
19. Under what conditions are submersible deep well turbine pumps commonly used?
20. Under what circumstances should a well be disinfected?
21. What chlorine compounds are commonly used to disinfect wells?