Pumps

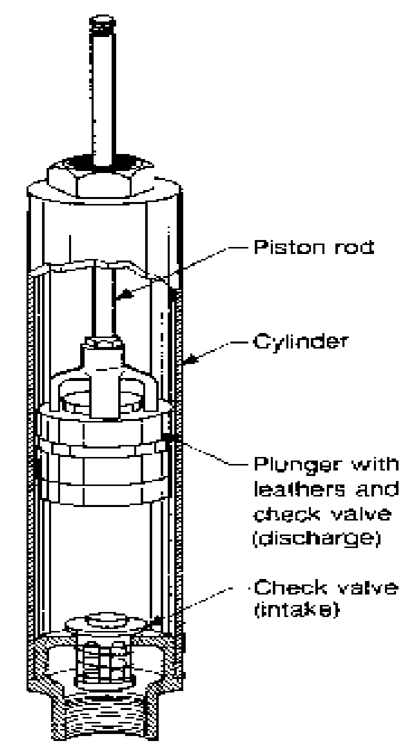
SELECTION OF A PUMP

A water system needs to move the water produced from the source to its customers. In almost all cases in Minnesota, the source is at a lower elevation than the user so the water must be raised to a higher level. Some type of pumping equipment must be used to generate the pressure for raising the water to the higher elevation.

Many different types of pumps can be used with the selection depending on the work that needs to be done. One type would be used for transferring water from a well to a tower; another would be better suited for pumping sludge containing a lime byproduct from a softening plant; still another would be used for feeding a chemical into the water for treatment. Among the considerations in selecting a pump are the maximum flow needed in gallons per minute (gpm), the head it needs to pump against, and the accuracy needed for flow control.

POSITIVE DISPLACEMENT PUMPS

The positive displacement pump is commonly used to feed chemicals into the water or to move heavy suspension, such as sludge. One type of positive displacement pump consists of a piston that moves in a back and forth motion within a cylinder. It is used primarily to move material that has large amounts of suspended material, such as sludges. The cylinder will have check valves that operate opposite to each other, depending on the motion of the piston. One check will be located on the suction side of the piston and will open as the piston moves back, creating a larger cylinder area. After the piston has reached the longest stroke position, the motion of the piston will reverse. This action will open the discharge check valve and close the suction check. The contents of the piston are then discharged to discharge piping. After the discharge, the motion of the piston will reverse and the suction stroke will begin. This action will take place as long as power is applied to the pump.

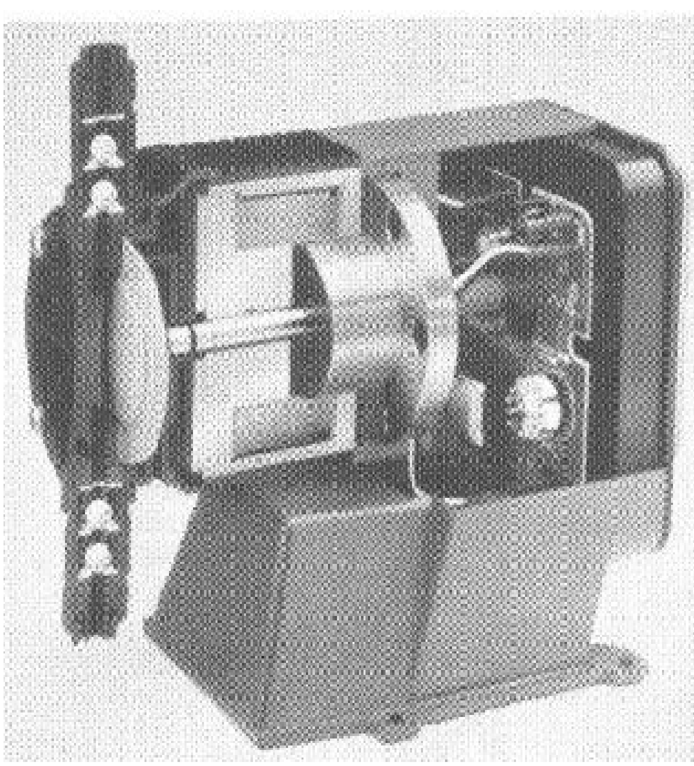


Sticks and stones and other material can become lodged in the check valves of a piston pump, reducing the pump's rate or stopping it completely. When this happens, the check covers must be taken off and the material removed. GREAT CAUTION SHOULD BE EXERCISED WHEN REMOVING THE COVERS SINCE PRESSURE MAY HAVE BUILT UP IN THE CHAMBER.

Because high pressure could damage parts of the pump or cause the piping material to fail, the positive displacement pump should never be throttled on the discharge side of the piston.

The power for a large piston pump is generally an electric motor connected to the piston by way of a gear head and connecting rod.

Another type of positive displacement pump used in the water industry is the diaphragm pump. This pump operates the same way as the piston pump except that, in place of a piston that moves in a cylinder, a flexible diaphragm moves back and forth in a closed area. The check valves operate in the same fashion as they feed or move liquid in the pump. This type of pump is used when high accuracy is required. Most of these pumps are operated by the use of a solenoid that will pulse a set number of times per minute. This pulsing, which is termed frequency, is variable and can be set by the operator or by a control signal. The length of the stroke can also be adjusted in order to vary the size of chamber that fills with liquid.



Larger diaphragm pumps may be operated by mechanical means in a fashion similar to the piston pump. The biggest difference is the replacement of the piston with a flexible diaphragm. The diaphragm is attached to a metal rod that is operated by an eccentric cam driven by an electric motor.

Large diaphragm pumps—used to move sludge or other liquids that contain large amounts of suspended materials—may be driven hydraulically with either oil or air used as the driving force. The material to be pumped will be on one side of the diaphragm with the air or oil on the opposite side. The problem with using this type of pump is that the driving material and the liquid could mix if the diaphragm ruptured.

Another drawback of the diaphragm pump is the pulsing action that the diaphragm generates within to the pumped material. This can often be overcome by the use of air chambers on the discharge side of the pump. One more disadvantage is that, if the pump is running slowly and discharging directly into a flow line, the chemical may not be mixed into the water. The reason being that water is running continuously at the injection point, but the chemical is added in pulses.

WHAT ARE CENTRIFUGAL PUMPS

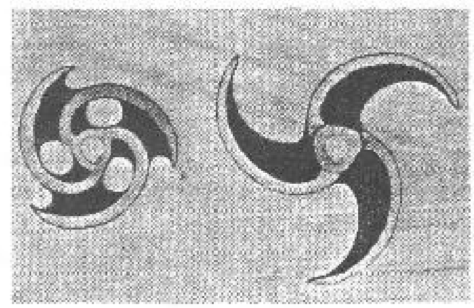
Because it delivers a constant flow of water at a constant pressure for any given set of conditions, the centrifugal pump is ideal for delivering water to customers. Most well pumps are centrifugal pumps. They are ideal for use in the distribution system since they do not produce pulsating surges of flow and pressure.

This pump operates on the theory of centrifugal force. As the impeller rotates in the pump case, it tends to push water away from the center of the rotation. As the water is pushed away from the center of the impeller, additional water is pulled into the eye, or center, of the impeller. The water that has been pushed to the outside of the impeller is removed from the pump through the discharge piping. This water will have a pressure that is determined by the pitch of the impeller and the speed at which the impeller is turning. There are many types of centrifugal pumps, but they all have major parts in common.

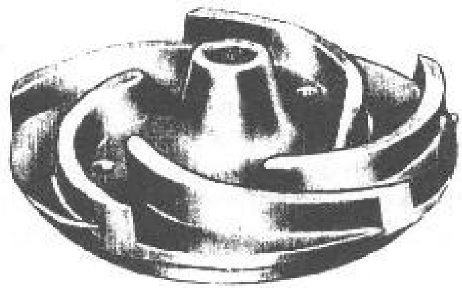
> Pump Case - The pump case or volute is designed to allow the liquid being pumped to move to the center of the impeller as well as to allow the water to be removed from the pump through the discharge. The case, which fits closely around the impeller on all but the discharge side, is made of cast iron or brass. If the liquid is abrasive or corrosive, other materials, such as a rubber lining, may be used.
>
> Impellers - The impeller generates the centrifugal force that moves the liquid. Variations in the impeller are based on whether a particular application calls for large quantities of water, high pressure, or both. The design of the impeller is important to the development of pressure and flow.

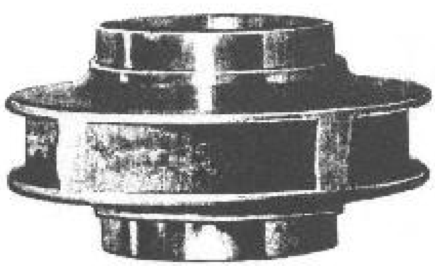
Impellers in centrifugal pumps can be classified by size, type, and speed. There are three types of impellers for centrifugal pumps:

Open Impeller



An open impeller has its vanes exposed on the bottom side, a design that allows the pump to move liquids that contain large solids. Open impellers are used in propeller pumps in which the head is low (usually less than 20 feet) and the volume of water pumped is high. The rate of flow can easily be set by adjusting the clearance of the bottom of the impeller to the pump casing. The larger the clearance is, the less will be pumped.





Semi-Open Impeller

This design contains many of the same characteristics of the open impeller. The semi-open impeller has a shroud, or cover, on one side. It is used to pump liquids that contain medium-size solids.

Closed Impeller

This is the impeller of choice in most pump designs and is used in cases where the liquid being pumped has few solids since it will pump the liquid with less wasted energy. With this design, there is a cover on both sides of the impeller with the vanes completely enclosed. The eye of the impeller is surrounded by a skirt, which fits into a recess in the pump casing and ensures that the water from the discharge side of the impeller does not recirculate back to the suction side. The impeller is set in the center of the pump casing.

The skirt of the impeller is surrounded by a wear ring to reduce problems which can seriously affect pump performance and the life of the impeller. The pressure inside the volute of the pump increases when the pump is operating. A zone of high pressure in the volute and low pressure in the suction eye is set up.

As the water jets from the high- to the low-pressure area, the material of the volute and impeller will be worn away. Abrasive material in the water can also contribute to the wear.

The wear ring on the impeller is designed to be a sacrificial element. It absorbs the wear, saving the impeller from damage. A certain amount of water is recirculated, causing energy to be wasted, as water jets from the high- to the low-pressure side of the impeller back to the suction eye. Normally the clearance can be adjusted to keep such recirculation to a minimum.

Centrifugal pumps can have more than one impeller, often called stage. Each additional stage increases the head that the pump can pump against. If one impeller will pump against 60 feet of head, two will pump against approximately 120 feet, three against 180 feet, etc. The rate of the flow in gpm will not be affected by additional impellers since that is dictated by the diameter of the impeller. It will be no greater than what the first impeller can deliver.

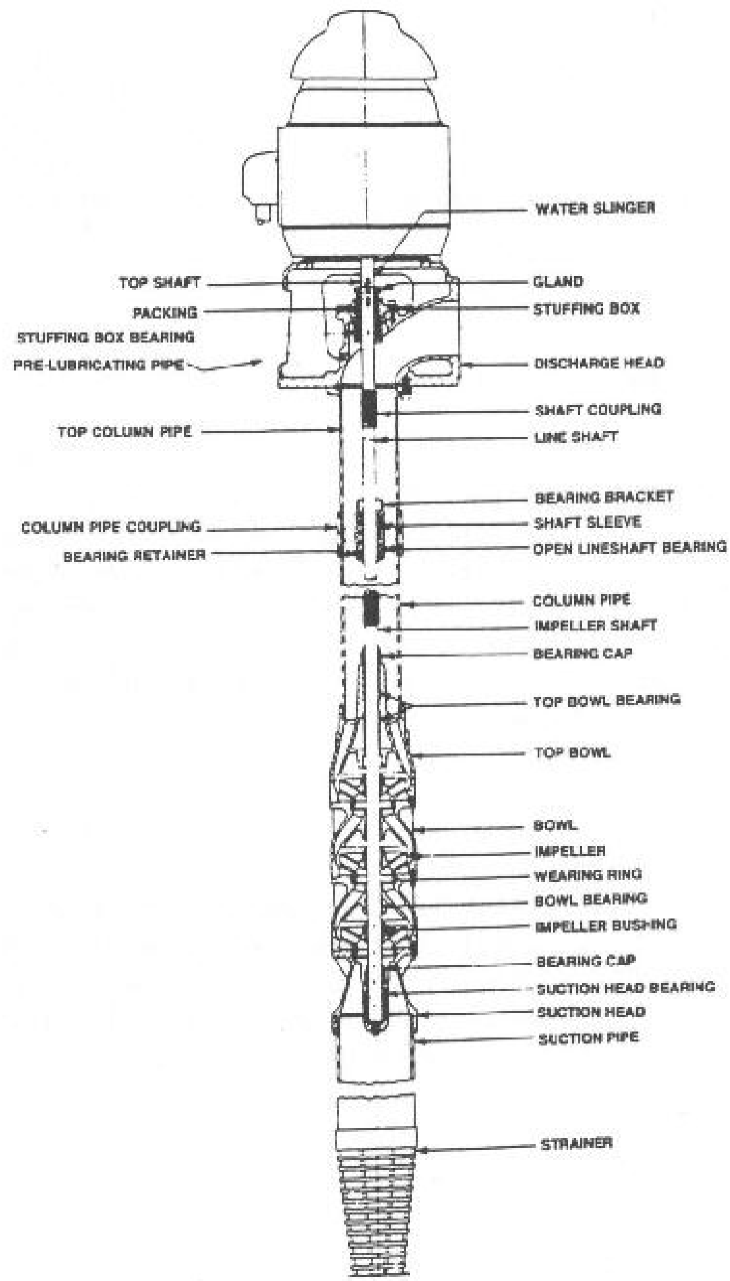
TYPES OF CENTRIFUGAL PUMPS

VERTICAL TURBINE PUMPS

A line shaft turbine pump is one of the most common pumps to be used in the water industry. The pump consists of bowls that contain the impellers, which are connected with each other through the pump shaft bearings.

A turbine pump will usually be staged with more than one impeller to overcome the head conditions that are encountered in the operation. The water from one stage will be discharged into the suction eye of the next stage, a process that will continue until the head is overcome. The size or diameter of the first impeller dictates the volume capacity of the pump in gpm.

The vertical turbine pump contains the following parts: power source, discharge head, pump column, pump shaft, shaft bearings, and the pump itself.



<u>Discharge Head</u>

The discharge head is designed to support the weight of the pump and column pipe along with the shafting. It connects the pump column to the discharge piping and contains the stuffing box that allows the pump shaft to pass into the column pipe. It is designed to contain the pressure the pump is creating.

Pump Column

The pump column, a pipe that connects to the bottom of the discharge head and supports the pump below, is generally ten feet long with a bearing contained in each coupling. The bearing, which is lubricated with the water being pumped, is made of brass and has a rubber insert in the retainer.

Pump Shafting

Pump shafting transfers the energy from the power source to the pump. It is generally made of steel and has stainless-steel shaft sleeves every ten feet. The pump shaft runs in the retainer bearings located between the column couplings. If the water is very corrosive, the entire shaft may be made of stainless steel or another corrosion-resistant material. The size of the shaft will vary with the size of the pump.

SUBMERSIBLE PUMPS

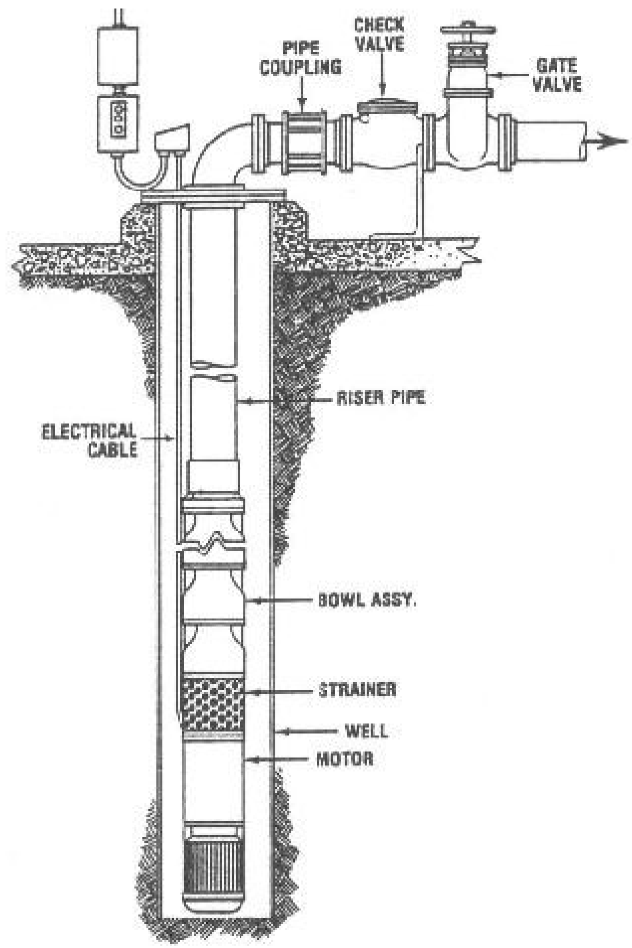
The submersible pump is especially suited to deepwell and booster service for industrial, commercial, and municipal water systems. The pump utilizes a submersible motor coupled directly to the bowl assembly and is designed to operate completely submerged in the fluid being pumped. Power is supplied to the motor by waterproof electrical cable. In deepwell applications the pump motor and cable are suspended in the well by the riser pipe. Booster applications involve installing the unit in a steel suction barrel or horizontally in a pipe line. Since the entire unit is either enclosed or below the surface of the ground, there are several applications where the submersible pump has many advantages.

- Extremely deep wells where problems with shafting are likely to be encountered (such as in crooked wells).
- In installations where flooding would damage standard above ground motors.
- Applications such as boosters pumps which require quiet operation.
- Installations where there is little or no floor space.
- Horizontal pipeline booster pumps placed directly in the pipeline where conditions require a minimum amount of excavation or use of land surface.
- Dewatering applications.

TYPICAL OPERATION

Submersible pumps may be operated and controlled in the same manner as any other type of turbine pump in similar applications. No special consideration peculiar to the submersible is generally necessary, with the exception of the motor starting equipment. The motor, being installed in the pumped fluid, may not be subjected to the same ambient temperature as the overload relays in the starter. It is usually best to use current sensing type overload relays under this condition rather than the thermal type.

CONSTRUCTION DETAILS



Surface Mounting Plate

The surface mounting plate holds the weight of the suspended unit and incorporates an elbow or fitting connected to the discharge piping. The surface plate also provides a junction box for terminating the electrical cable from the pump motor.

Rise Pipe

The riser pipe connects the submersible pump to the surface plate. The pump discharges through this pipe to the surface. It may be several hundred feet long in a deep well application or a short connection piece in a booster pump.

Electrical Cable

The waterproof electrical cable extends from the top of the unit to the surface.

Pump Bowl Assembly

The Pump Bowl Assembly consists of single or multiple stages to meet exact system head requirements. A wide range of bowl sizes is available to meet system capacity requirements. Standard construction includes cast iron bowls with bronze impellers on a stainless steel pump shaft. A suction strainer is used to prevent foreign objects from entering the pump.

Electric Motor

The submersible Electric Motor is attached to the lower end of the bowl assembly becoming an integral part of the submersible unit. The motor thrust bearing carries the thrust load of the pump.

Suction Barrel

For booster service a Suction Barrel may be utilized. Its size will depend on specific installation requirements. For high pressure allocations the suction barrel is extended to accommodate additional bowls.

Low Lift Centrifugal Pumps

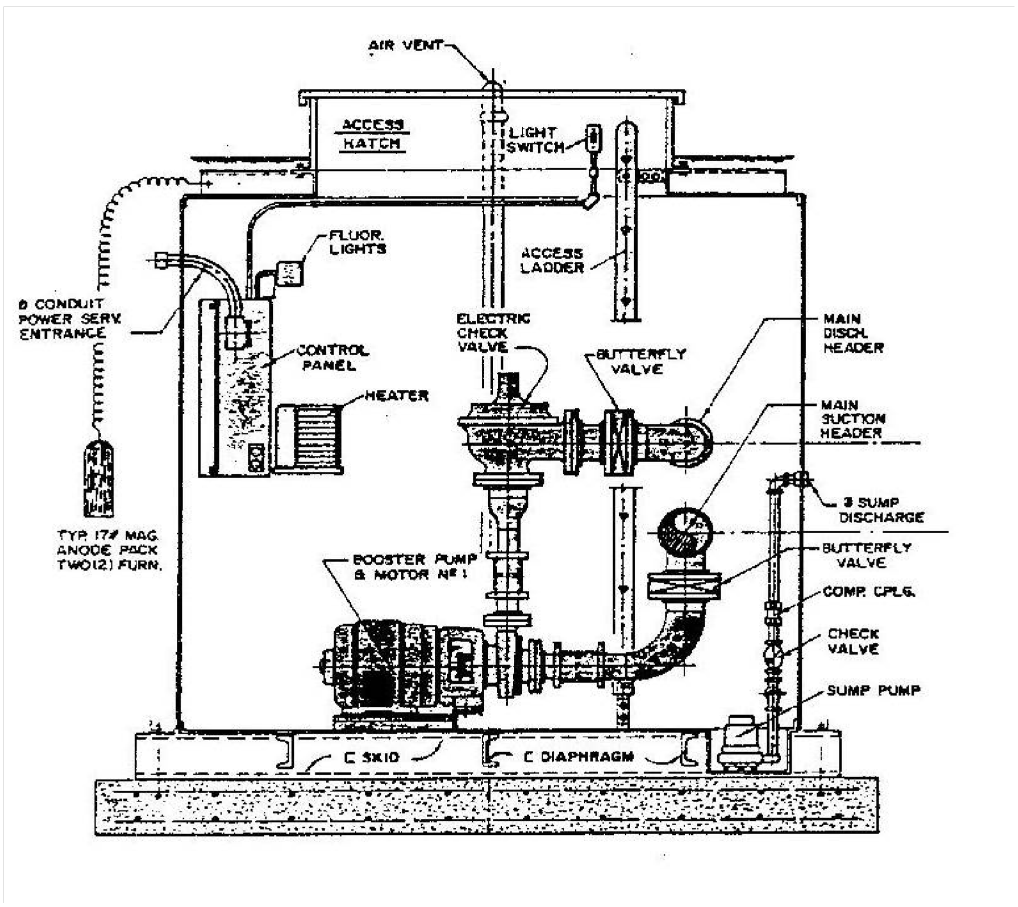
Among other uses, these are used to pump water from at surface source to a treatment plant.

High Lift Centrifugal Pumps

These are used to pump water from a treatment plant to the distribution system.

Booster Pumps

These are used to increase water pressure in the water distribution system.



PUMP SELECTION & PUMP CURVE

The selection of a pump for a particular condition should be approached with as much information as possible about the conditions under which it will operate. One piece of information necessary is the total dynamic head, which consists of the sum of all heads that the pump must overcome in its operation, the gpm to be moved, size of well casing (if needed), the revolutions per minute (rpm) of the power source, and the depth of setting.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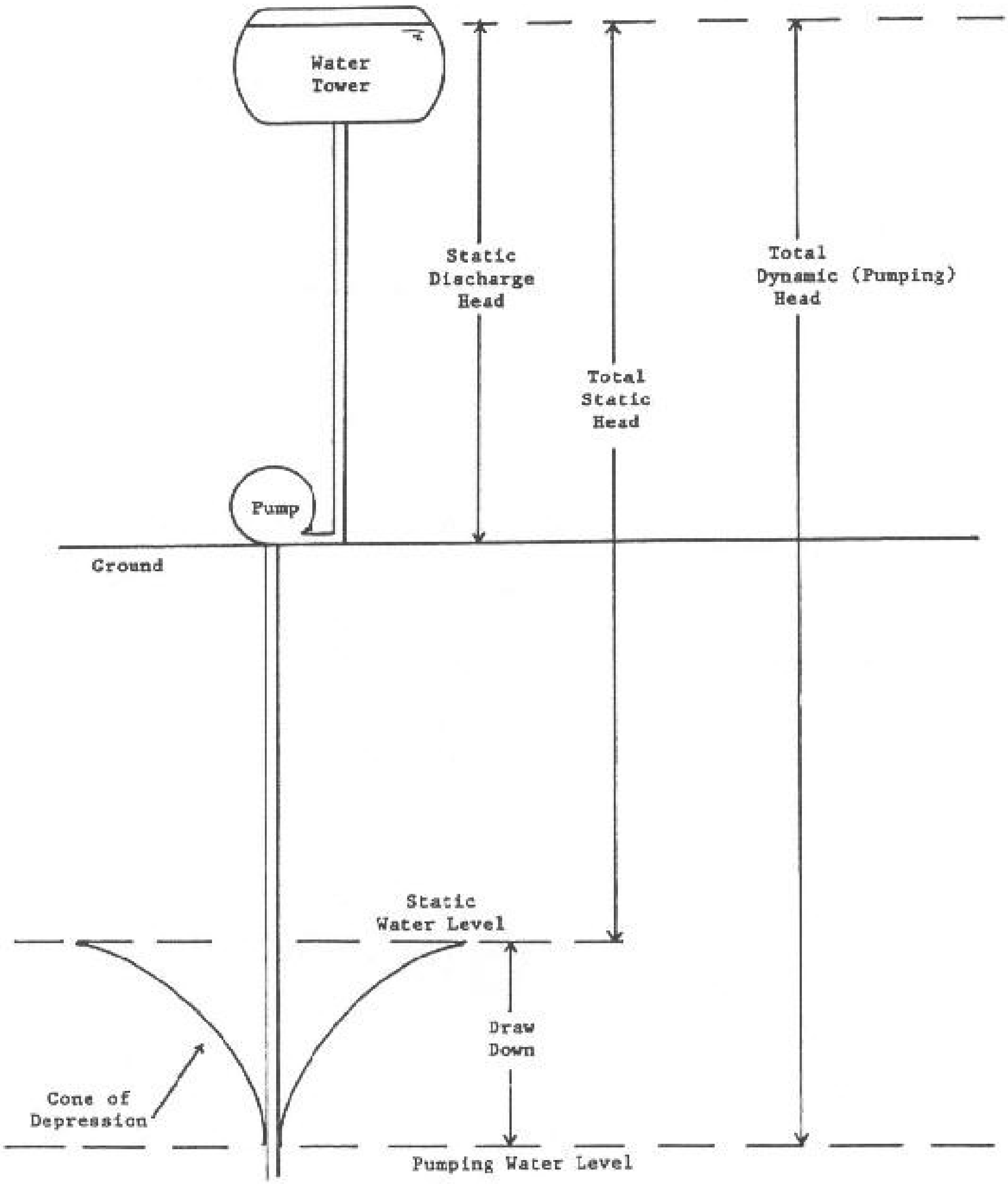

Water Tower
Static Discharge Head
Total Dynamic (Pumping) Head
Total Static Head
Pump
Ground
Static Water Level
Draw Down
Cone of Depression
Pumping Water Level

With this information, the operator can make a decision of the type of impeller that would be the most efficient and use the least energy.

The following information may be found on a pump curve:

<u>Size of Bowl</u>

The pump curve contains the diameter of the bowl. If the bowl is too large, it may not fit into the well casing.

<u>Size of Impeller</u>

The size of the impeller will also be on the pump curve sheet. Shown by an A, B, or C on the curve, this indicates the trim, or size, of the impeller. The A curve shows the characteristics of a pump with the largest diameter impeller, with the impeller for the B and C curves decreasing in size.

<u>Bowl Head</u>

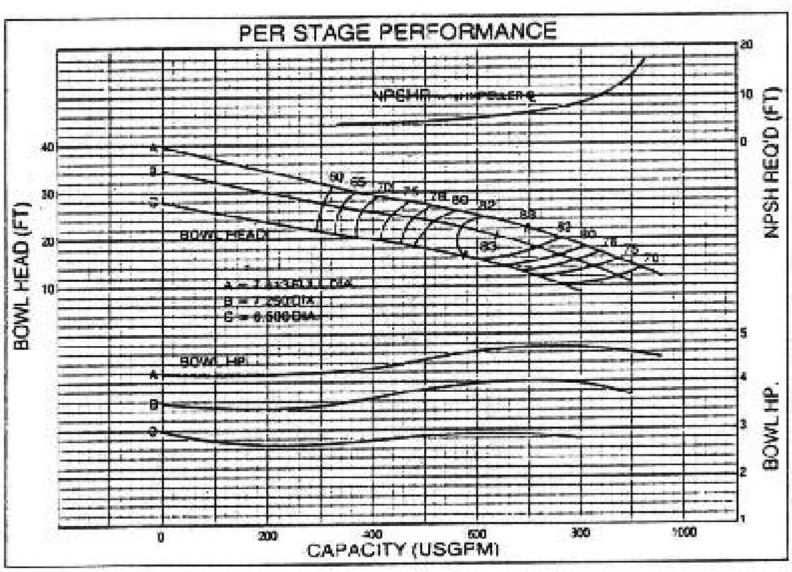
The curve indicates the head that one impeller will overcome. This information is contained along the right-hand side of the graph and is calibrated in feet rather than pounds per square inch (psi).

<u>Capacity</u>

The flow in gallons per minute is along the bottom of the graph.

<u>Pump Efficiency</u>

Efficiency should be a top priority in the selection of a pump. The pump efficiency is found by drawing a line from the gpm that is expected from the pump and a line from the head, in feet, that is expected. If the head is greater than one impeller can overcome, the bowls will have to be staged with additional bowls. This can change the pump’s efficiency. A pump with only one bowl usually has a greater loss than a pump with many bowls, or a staged pump.



PUMP DRIVES

The pump needs a means of rotating the impellers. The most common source of power is the electric motor, which is often the squirrel-cage type with a constant speed and torque. Electric motors are an attractive choice due to their reliability.

Information needed to select the correct size of electric motor for a particular application is the gpm, total head, motor efficiency, and pump efficiency.

As the motor rotates the shaft, it lifts a quantity of water from the well or reservoir to a higher elevation or pressure zone. The horsepower required is in direct proportion to the weight of the water being lifted each minute.

One horsepower is equal to 33,000 foot pounds per minute. This means that one horsepower will lift 33,000 pounds of water one foot in one minute. This formula is shown below (remember that a gallon of water weighs 8.34 pounds):

$$\text{MOTOR HP} = \frac{\text{GPM x 8.34 \#/gal x head}}{\text{33,000 ft lbs./min. x pump eff. x motor eff.}}$$

This may be simplified by dividing the 33,000 by 8.34 to give you 3960. Thus:

$$\text{MOTOR HP} = \frac{\text{GPM x HEAD}}{\text{3960 x P eff. x M eff.}}$$

The highest voltage available in the area should be used when selecting the motor since this will lower the amperage that, in turn, reduces the size of all the wiring that is required to operate it.

PUMP OPERATION AND MAINTENANCE

Both the pump and its motor need regular maintenance.

MOTOR MAINTENANCE

Information on the maintenance of the motor should be available in the manufacturer manual supplied with the motor. It includes the types of oils or greases to be used and how often the equipment should be lubricated.

Maintenance of the insulation inside of the motor is a difficult, but important, task. It needs to be kept dry, cool, and clean, free of contaminants such as dust, salts, chemicals, lint, and oil. It is important to clean the vents to keep them open.

Some insulation is porous and can absorb water, causing failure of the motor. Dirt and other contaminants attract moisture, as well, and reduce the life of the motor. The proper enclosure can eliminate most of the problems of moisture.

Contamination problems are often attributable to substandard greasing practices or to water contamination from flooding or excessive packing leakage.

Lubrication of the pump should follow the recommendations of the manufacturer. All fittings and grease cups should be cleaned before greasing to remove any dirt that has built up on them. The relief plug should be removed from the bearing. This allows the old grease to be removed from the bearing case as the new grease is pumped in. This practice prevents the old grease from entering the windings of the motor.

The motor's electric operating conditions—useful information for the operator—are easy to obtain. The voltage and amperage should be measured at least yearly. CAUTION SHOULD BE PRACTICED DUE TO THE DANGER OF ELECTRIC SHOCK. IT MAY BE ADVISABLE TO HAVE A QUALIFIED ELECTRICIAN TAKE THESE MEASUREMENTS FOR YOU.
Measurements that change greatly could be an indication of problems with the motor or pump. A drop in voltage will result in a corresponding increase in the amperage.

PUMP MAINTENANCE

The only maintenance needed for a line shaft turbine pump is checking the packing gland for excessive leakage and repacking as needed. If the leakage at the packing gland is excessive, the operator should tighten the packing gland follower until the water loss is reduced, but the leakage should not be completely stopped since water serves as the coolant for the packing in the stuffing box.

When the follower cannot be tightened anymore, the packing has to be removed and new packing installed. NEW PACKING SHOULD NEVER BE ADDED ON TOP OF THE OLD.

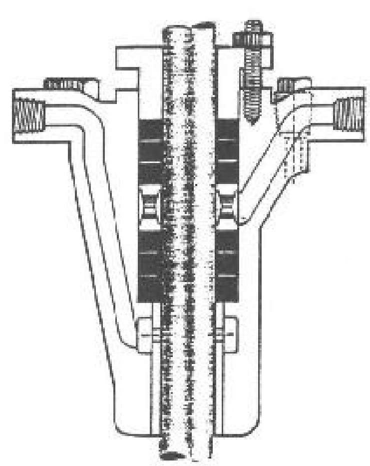
CAUTIONS WHEN SELECTING PUMP PACKING

Most types of pump packing have been developed to meet specific needs and are not usable in the water industry. Even so, there is a large selection of packings available for the waterworks operator to use. The most common types of packing used in the industry today are made of graphite or Teflon. The selection depends on the pressure and speed of the pump shaft. The following table shows the types of packing available:

MATERIAL	pH RANGE	SHAFT SPEED, FT/MIN	TEMPERATURE LIMITS
Vegetable fibers	6-8	Variable	225° F
Cotton			
Flax			
Hemp			
Jute			
Ramie			
Mineral fibers		Variable	50° F
White asbestos………….	4-12		
Blue asbestos………….	2-10		
Pure Teflon………………	0-14	600 ft/min	600° F
Pure Graphite…………...	0-14	400 ft/min	+ 3000-5000° F

All of the old packing should be removed along with the lantern ring when repacking a pump. Proper tools should be used for the removal. Ice picks or screwdrivers may damage the sleeve or some other part of the stuffing box. The old packing should be inspected for any unusual wear.

The new packing used should be cut to fit around the shaft with no opening left at the packing joints. This can be done by wrapping the packing around a sleeve and cutting the packing into pieces. This will assure that the packing is the proper length and will fit the stuffing box. After the old packing has been removed from the pump, the stuffing box should be washed out with water to remove any other material. The new packing can then be installed. The second piece of packing should have the joint offset from the first packing to prevent water from escaping through the joints in the packing. This process should be followed until the stuffing box is full. The follower should then be installed on top of the packing and tightened lightly. The tightening should be continued after the pump is started until the leakage is controlled. It is considered controlled when the leakage is reduced to about 20 drops per minute.



It is now common to have a mechanical seal instead of packing. They are more expensive, but their maintenance is low.