Maintaining Wastewater Equipment

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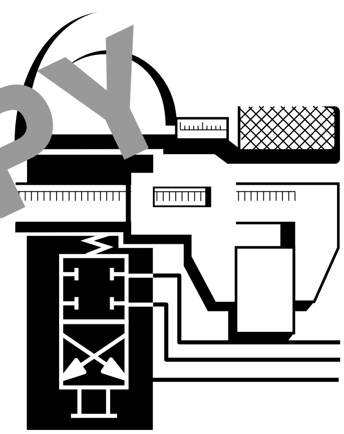
MAINTAINING WASTEWATER EQUIPMENT

Lesson One

Pumping Stations



TPC Training Systems

38301

Lesson

1 Pumping Stations

TOPICS

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OBJECTIVES

After studying this Lesson, you should be able to…

- Describe a typical collection system layout.
- Name the three types of pumping stations currently in use and explain how they differ.
- Use the following terms in an explanation of pump operation: impeller, shroud, volute case, stuffing box, shaft sleeve, wearing ring.
- Name the importance of a pump station ventilation system.
- Demonstrate the necessary procedures to follow before pump start-up.

KEY TECHNICAL TERMS

Manhole 1.03 a collection system entrance point

Dry-well station 1.05 a pumping station in which motor and pump are removed from the sewage system

Wet-well station 1.06 a pumping station in which pump or motor and pump are submerged in sewage

Impeller 1.11 a propeller-like device that pushes fluid through a pump

Stuffing box 1.14 the place where the pump shaft passes through the volute case

Shaft sleeve 1.17 a sleeve that protects a pump shaft from wear

Wearing ring 1.17 a ring that protects an impeller from wear

Ideally, wastewater flows through a collection system by gravity. However, pumping stations sometimes are necessary to raise the water to a higher level so that it can continue flowing toward the treatment plant.

To keep a pumping station working properly, it is important that you understand how the different types of stations work and how they can be maintained safely and effectively. This Lesson describes the three main types of pumping stations and their major parts. It also details station start-up, operation, and shutdown. The maintenance and safety aspects of pumping station equipment also are covered in detail.

Collection Systems

1.01 A *collection system* is an underground, watertight conduit used to convey sanitary waste and, in some cases, storm water from urban areas to disposal points. Collection systems also are known as *sewers*.

1.02 A collection system is composed primarily of three elements—piping, manholes, and pumping (or lift) stations. A common layout for a collection system, as shown in Fig. 1-1, includes the *house service*, which is usually a 4-in. or 6-in. line slightly sloped so that gravity will convey the waste. House services are connected to *laterals*, which again carry the waste by gravity. Laterals are usually 6 in. or larger in diameter. Laterals connect into a *trunk line* (or main line) through which the waste flows to the treatment facility.

1.03 *Manholes* are points of entrance for the purpose of collection system maintenance. They usually are made of concrete and have cast iron covers. Manholes are installed at each change in elevation or direction and approximately every 300 to 500 ft along straight runs.

Pumping Stations

1.04 It is desirable to allow sewage to flow to the treatment plant by gravity. However, when hilly terrain and deep excavation make this impossible, pumping stations are used. In this case, the sewage is allowed to flow into a basin. From the basin, the sewage either is pumped up to some point and allowed to continue flowing by gravity from there, or it is pumped directly to the treatment plant. There are three types of pumping stations currently in use—the wet well, the dry well, and the pneumatic ejector.

Fig. 1-1. Collection system layout

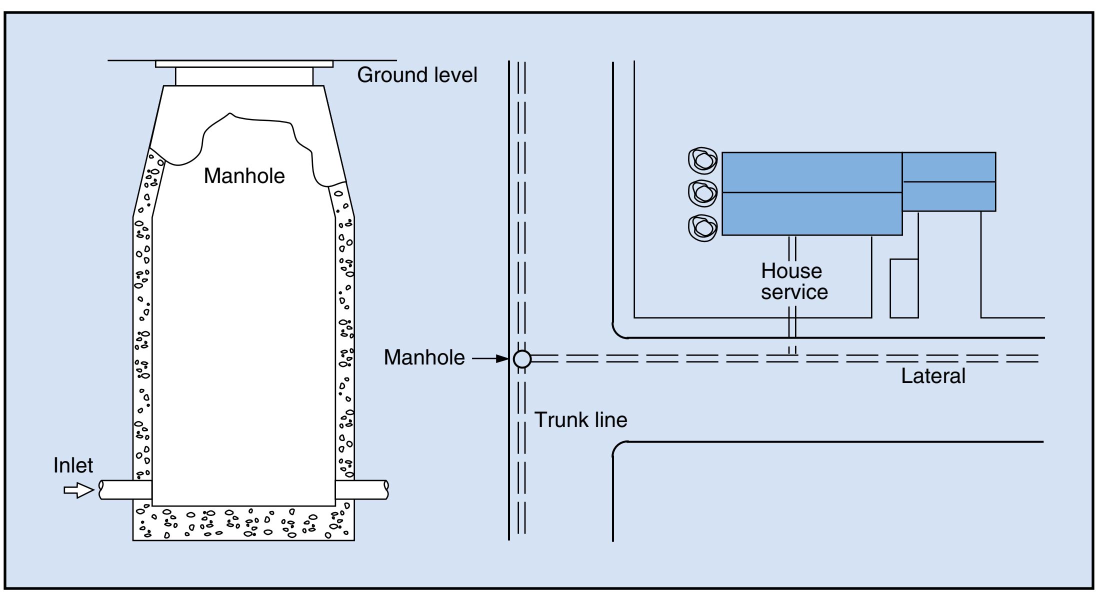


Fig. 1-2. Dry-well pumping station

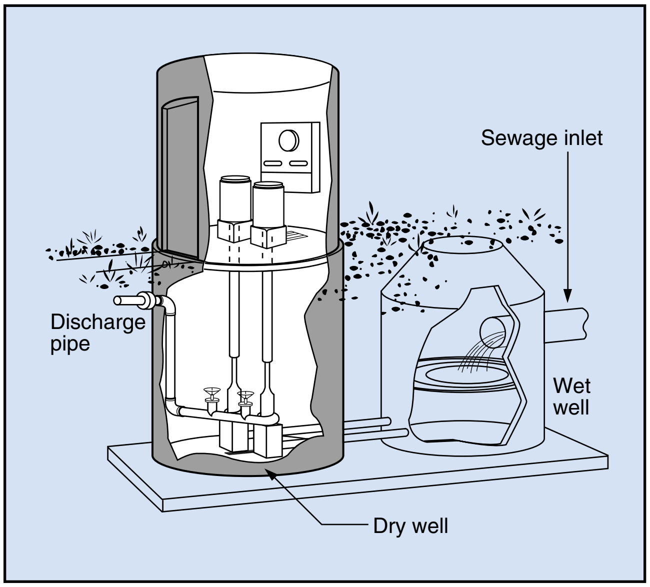
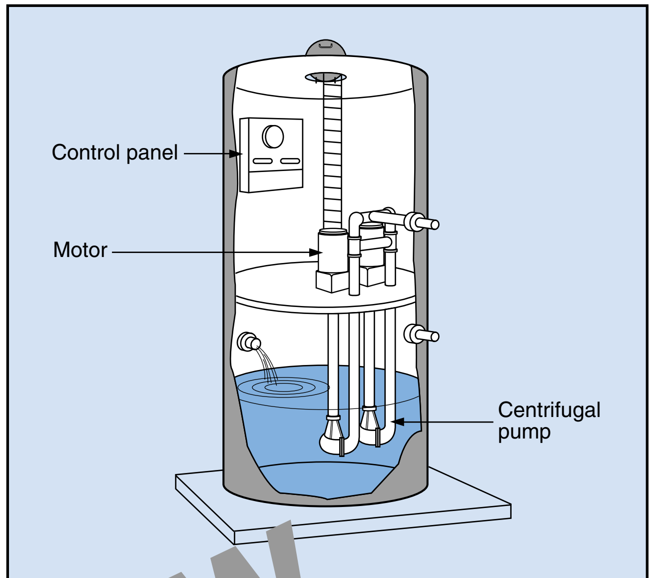


Fig. 1-3. Wet-well pumping station



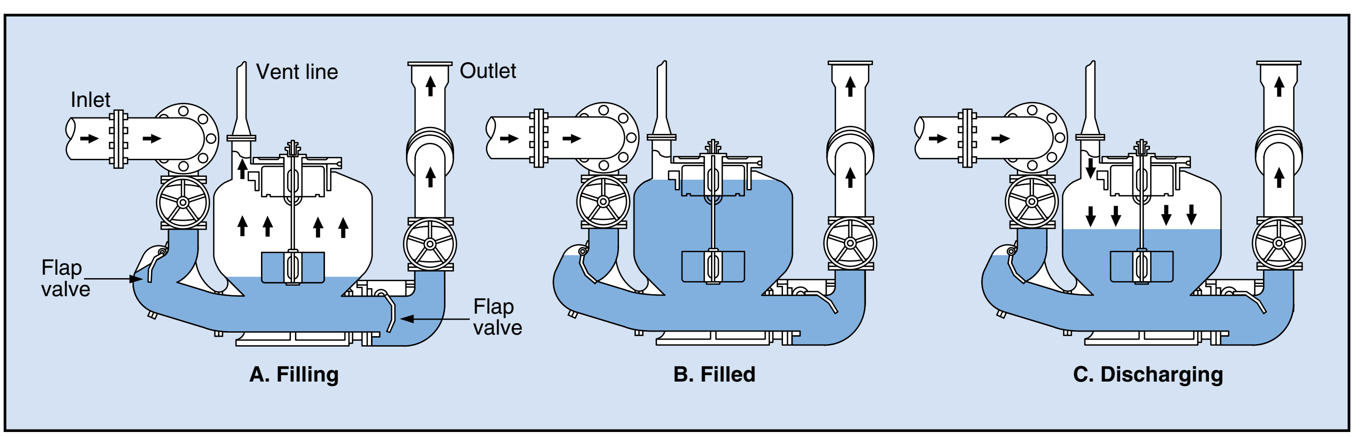
1.05 *Dry-well* pumping stations are those that have the motors and pumps in an area that is separated from the wet well. The wet well is where the sewage collects. Figure 1-2 shows the general layout of a dry-well station. Sewage is pumped from a wet well that is usually adjacent to the dry well. This type of facility is the most desirable from an operational standpoint for the obvious reason that during routine or emergency maintenance, the equipment is not submerged in raw sewage.

1.06 *Wet-well* pumping stations, like the one shown in Fig. 1-3, have either the pump or both the motor and the pump submerged in the sewage. Wet-well stations are usually less expensive to construct than dry-well stations, but they are more expensive to maintain. Normally, wet-well stations are employed only in those low-flow systems that do not exceed 2500 gpm.

1.07 The *pneumatic ejector* is a special type of pump and pumping station. The unit consists of one or two airtight containers, each with a capacity of 50 gal or more. Piping is connected to the containers and houses a flap valve on both the discharge and entrance lines. The unit includes a control circuit and an air supply.

1.08 When the unit is empty, sewage enters the inlet line, pushes the flap valve open, and flows into the tank,

Fig. 1-4. Pneumatic ejector



as shown in Fig. 1-4A. As the tank fills, air escapes through the vent line. The discharge valve is closed by the back pressure of the sewage. When the tank is full, as shown in Fig. 1-4B, a signal is sent to the air supply. The signal is obtained either electrically, from two electrodes in the tank, or mechanically. The air supply generates a pressure sufficient to close the inlet valve and push the sewage out through discharge piping, as shown in Fig. 1-4C. Then the cycle is repeated.

1.09 Some pumping stations are prefabricated and simply installed in a hole in the ground. These are called *packaged stations*. These smaller pumping stations usually are scattered throughout the collection system, and operators check them and perform maintenance on a daily route. There are also large pumping stations that pump millions of gallons of wastewater each day. These stations usually have a full-time operation and maintenance crew.

Pumping Station Components

1.10 Wet-well and dry-well stations have similar components. The basic components include some type of centrifugal pump, a sump or drainage system, the pump drive unit (usually an electric motor), a backup power system, the piping system, a gas removal or ventilating system, and the pump control system. Each of these components will be covered in the following paragraphs.

Pump Operation

1.11 The pump most commonly used in a typical lift station is the centrifugal pump. The centrifugal pump is composed of a shaft that is mounted in two bearings set into a housing. Attached to the end of the shaft is the heart of the pump, called the *impeller*. The job of the impeller is to transfer energy from the shaft to the water.

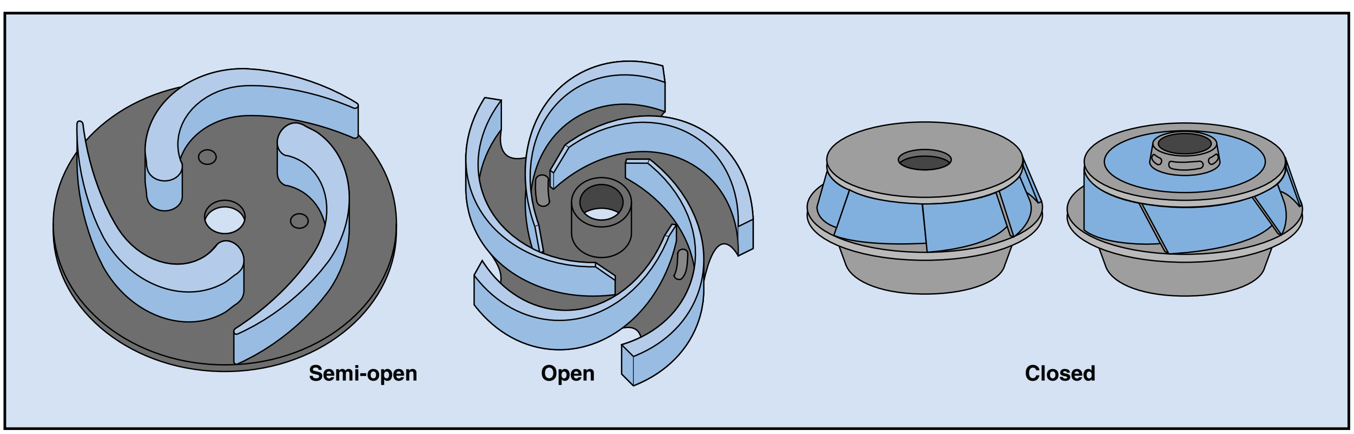
1.12 There are three types of impellers—open, semi-open, and closed. An example of each is shown in Fig. 1-5. The semi-open is probably the easiest to understand. It contains a back plate, called a *shroud*, with one or more vanes attached to it. The open impeller has no back shroud, only vanes attached to a central area. The closed impeller has a shroud both front and back with vanes between the shrouds.

1.13 Open and semi-open impellers are the most common in wastewater operations, since they can pass larger solids than a closed impeller can. However, both the open and semi-open types are less energy-efficient than the closed impeller, and this has caused more emphasis lately on the use of closed impellers.

1.14 The impeller is surrounded by a metal component, referred to as the *volute case*. The place where the shaft passes through the volute case is called the *stuffing box*. Packing or mechanical seals are used to control leakage between the pump shaft and the stuffing box. The packing is held in place by an adjustable ring called a *packing gland*. When a mechanical seal is used, the gland is called a *seal gland*.

1.15 Packing is made of some type of fibrous material, such as asbestos, flax, jute, or cotton, and is used with some type of lubricant, such as oil,

Fig. 1-5. Centrifugal pump impellers



graphite, or Teflon®. The fibrous material usually is woven or braided into a square rope. Pieces of this rope are cut into lengths and placed around the shaft and into the stuffing box. Pressure by the packing gland pushes the packing against the rotating shaft, thus reducing the leakage to a manageable level.

1.16 A mechanical seal is made from two pieces of solid material, one softer than the other. One of the components (usually a hard ceramic) is held stationary in the stuffing box, as shown in Fig. 1-6. The other piece (usually a soft carbon) is attached to the shaft and rotates against the stationary component. The clearance between the faces of the two components is small enough to prevent nearly all leakage. A small amount of leakage between the faces provides the lubrication necessary for long seal life. The leakage should be so slight, however, that it cannot be seen by the operator.

1.17 To increase the life of pumps, manufacturers often install *shaft sleeves* in the stuffing box area. These shaft sleeves usually are made from stainless steel or bronze and are designed to protect the shaft from wear by the packing. A similar component is the *wearing ring*. The wearing ring is placed near a closed impeller and is itself worn by the passage of water and grit between the case and the impeller. In this way, it protects the case.

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1.18 The impeller is turned by the shaft. As the impeller spins, the vanes slide through the water. As the water slides over the vanes, friction causes energy to be transferred from the impeller to the water. The water then is thrown by centrifugal force away from the impeller. The volute case redirects the flow to a single direction. As centrifugal force throws the water away from the impeller, it leaves a void or vacuum at the center, or eye, of the impeller. This vacuum allows atmospheric pressure to push water into the void, and thus the pump keeps pumping water.

Pump Types

1.19 Centrifugal pumps are classed in a number of ways. Two of the most common are configuration and flow pattern.

1.20 Two centrifugal pump configurations are commonly used in lift stations—the frame-mounted pump, as shown in Fig. 1-7, and the close-coupled pump, as shown in Fig. 1-8. In the frame-mounted pump, the pump shaft and the pump bearings are separate from the motor shaft and the motor bearings. In the close-coupled pump, the motor shaft and motor bearings and the pump shaft and pump bearings are the same.

1.21 The close-coupled pump is usually less expensive to purchase than the frame-mounted pump, and it also takes up less space. If you hear the term

Fig. 1-6. Mechanical seal

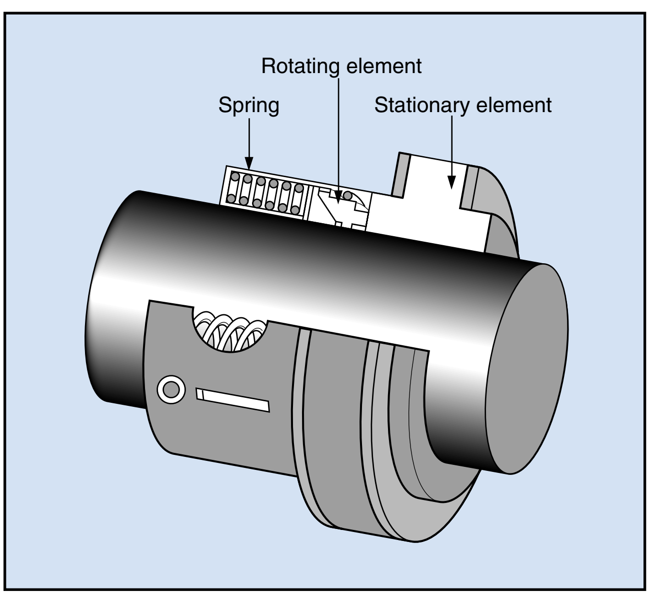
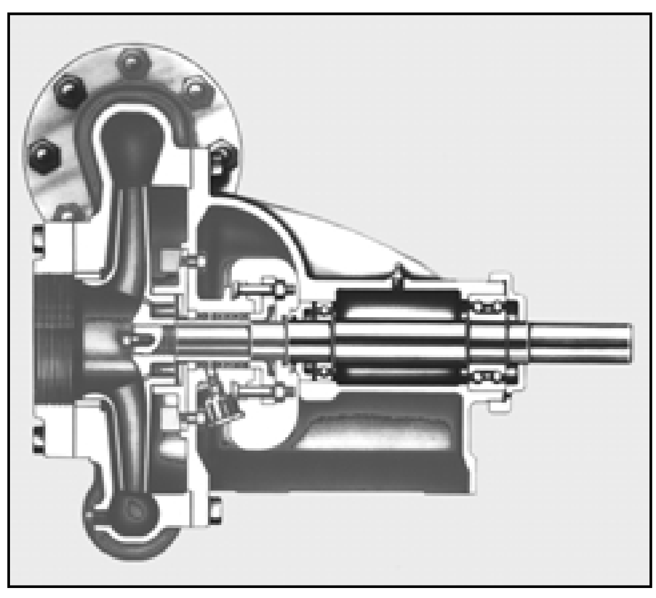


Fig. 1-7. Frame-mounted pump

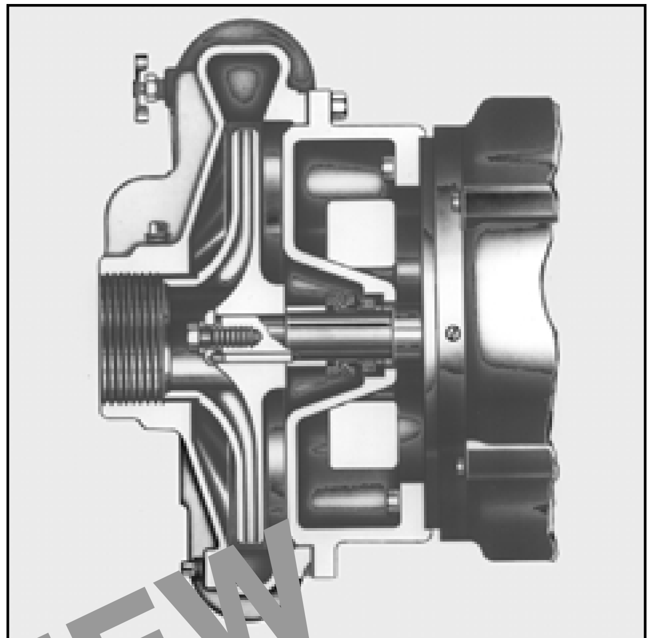


submersible pump, it refers to a close-coupled pump and motor that are designed to operate under water. Small submersible pumps (called *sump pumps*) are commonly installed in the pump room of dry-well pumping stations to pump out small quantities of water. They are built into a sump in the floor and pump accumulated water back to the wet well.

1.22 All of the pumps referred to so far in this Lesson are called *end-suction centrifugal pumps*, because water comes in the end of the case. These pumps also are called *radial-flow pumps*, because the water makes a right turn inside the case. In some large storm water pumping stations, axial-flow pumps are used. *Axial flow* means that the water flows straight up the shaft. This type of pump does not make use of centrifugal force, but instead works with a wedging action, much like the propeller of a boat. In fact, the pumps often are called *propeller pumps*.

1.23 The *vortex pump* normally is classified as an end-suction centrifugal pump, but the flow pattern within the pump has some special variations. As the impeller spins in the water, the energy transferred to the water causes the water to spin in the pump case. The spinning is transferred down the suction line, much like the vortex that is created when a plug is pulled in a sink. This vortexing action causes a small vacuum to form at the eye of the impeller, and the water is thrown from the case. The advantage of this type of pump is that it is able to pump material that contains large amounts of solids without plugging.

Fig. 1-8. Close-coupled pump



However, this type of pump is less energy-efficient than a normal end suction pump.

The Programmed Exercises on the next page will tell you how well you understand the material you have just read. Before starting the exercises, remove the Reveal Key from your Trainee's Guide. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.

1-1. List the three main parts of a collection system.	1-1. PIPING, MANHOLES, and PUMPING STATIONS Ref: 1.02
1-2. If possible, sewage should be allowed to flow to a treatment plant by means of ________.	1-2. GRAVITY Ref: 1.04
1-3. A pumping station in which both motor and pump are submerged in sewage is called a(n) ________ station.	1-3. WET-WELL Ref: 1.06
1-4. What type of pump is used most often in lift stations?	1-4. CENTRIFUGAL Ref: 1.11
1-5. Name one advantage of a closed impeller.	1-5. ENERGY EFFICIENCY Ref: 1.13
1-6. Pump packing is held in place with a ring called a(n) ________.	1-6. PACKING GLAND Ref: 1.14
1-7. Shaft sleeves are used to protect a pump shaft from ________.	1-7. WEAR Ref: 1.17
1-8. In dry-well stations, small submersible pumps are often used as ________ pumps.	1-8. SUMP Ref: 1.21

Pump Maintenance

1.24 A good preventive maintenance program should include lubrication, packing replacement, and the occasional replacement of shaft sleeves, wearing rings, mechanical seals, and impellers.

1.25 Always lubricate pumps according to the manufacturers' recommendations. The lubrication schedule should be more frequent for damp or dusty conditions, for longer running times, and for larger-horsepower equipment. Since selection of the proper lubricant is a critical factor for good operation, follow the recommendations of the lubricant and bearing manufacturers carefully.

1.26 Packing should be replaced when tightening the packing gland with a small-end wrench will no longer control leakage. Proper packing selection is important to packing life. The packing should be the proper size and should be cut in individual rings. The ends of the packing should be parallel but should not touch when installed. The packing joints should be staggered 90° to prevent excessive water loss. The packing should be allowed to leak in accordance with the manufacturer's recommendations.

1.27 Check the pump condition before replacing packing. The shaft runout should not exceed 0.003 in. If it does, the packing life will be drastically reduced.

1.28 Shaft sleeves are intended to wear, thus protecting the shaft. They can be removed by cutting with a chisel, turning on a lathe, or by peening with a ball peen hammer. New sleeves should be heated gently before they are installed.

1.29 Wear rings require special removal techniques, such as turning on a lathe, drilling, or removing with an arc welder. They are cooled with frozen CO_2 or Freon® before they are installed. It is important that the clearance between the wearing rings and the impeller be within the manufacturer's recommended limits.

1.30 Impellers should be replaced when they are worn enough to reduce the pump flow or pressure. The new impeller should be the same size and shape as the original impeller. If the impeller is larger, it will transfer more energy to the fluid and thus draw more current and cause the motor relays to disengage.

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1.31 Mechanical seals are highly machined devices that should be installed only when pump shaft runout does not exceed 0.001 in. per inch of shaft diameter. End play should not exceed 0.005 in. The seal should be handled with surgical gloves and should be installed in a clean environment.

Pump Drive Units

1.32 Two types of drive units are commonly used to supply power to centrifugal pumps—electric motors and internal combustion engines. The electric motors used in wastewater applications are typically the three-phase type. A three-phase motor is one that is supplied by three ac power sources. Each source is out of phase with the others—that is, each reaches its maximum voltage at a slightly different time. The major advantage of using three-phase motors is that they are able to start a load without using external or internal switches or capacitors. The electric motor is connected to a power source and to a control system that tells the pump when to turn on and when to turn off. The control system will be discussed in more detail later.

1.33 A typical power circuit consists of several components. The line from the power pole to the installation is called a *drop*. A typical three-phase system has four wires in the drop. The drop is connected to a weather head and then through the electric meter. From the meter, power is fed to the control panel. Inside the control panel is the magnetic breaker (or fuses). Both serve the same purpose—they protect the motor from electrical shorts. From the breaker, power flows to the magnetic starter. The starter is nothing more than a big switch that is controlled by an electromagnet. Power flows from the starter directly to the motor. The magnetic starter electromagnet is controlled by the automatic controls.

1.34 Internal combustion engines normally are used only to power backup generators. These engines may be powered by natural gas, methane gas, or diesel fuel. The generator usually is connected to the power supply automatically when there is a power failure.

Piping System

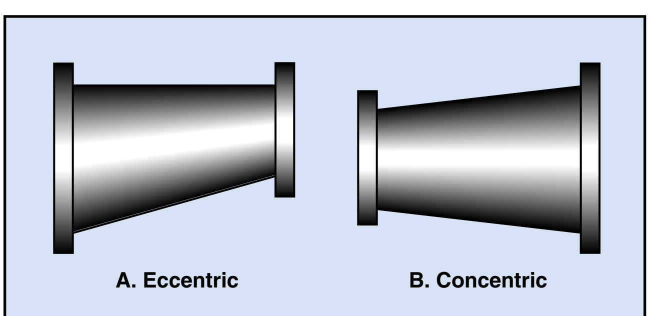
1.35 The piping system can be divided into two sections—suction and discharge. The *suction* piping is the more critical of the two portions of the system, and every attempt should be made to reduce the possibility of restriction. The suction piping is usually one pipe diameter larger than the inlet connection to the pump, and the inlet is usually belled. Both of these factors tend to reduce friction losses.

1.36 To isolate the pump for maintenance, valves are installed on the suction and discharge sides of the pump. The valve on the suction side should be a gate valve. It should always be kept in a fully open position, except during pump maintenance. A partially closed valve will cause cavitation, which eventually can and will damage the pump. When the pump is mounted horizontally, the suction piping should be connected to the pump with an eccentric pipe reducer (see Fig. 1-9A). The top of the reducer should be in line with the top of the pump inlet. This will prevent the accumulation of air in the suction line and thus the loss of prime in the pump. (When air enters the volute case, the vacuum is broken and the pump is said to have lost its prime—it will no longer pump water.)

1.37 The *discharge* piping usually consists of a concentric pipe increaser (see Fig. 1-9B), a check valve, and an isolation valve. Normally the check valve is a swing check type and is used to prevent water on the discharge side of the pump from running backward through the pump when it is off.

1.38 The best type of isolation valve is the gate valve, because it leaves an unrestricted path when in the fully open position. Some installations use butterfly valves. However, because the butterfly is in the flow path, even when in the fully open position, it may catch scraps of material and plug the line.

Fig. 1-9. Pipe reducers



This rag problem also causes trouble when you try to close the valve.

Ventilation System

1.39 Because the pumps in a pumping station are below the ground and are pumping sewage, it is possible that noxious or explosive gases (such as methane or hydrogen sulfide) could accumulate in the station. These gases can cause physiological damage on their own, or they can displace the oxygen in the area. In either case, death or permanent physical damage could result. Also, a corrosive atmosphere can damage the equipment and electronic controls in the dry well.

1.40 In order to reduce the risk of entering a pumping station, each station is equipped with a gas removal or ventilation system. There are two typical systems. One kind contains a small exhaust fan, either at the top or at the bottom of the station. The other forces air from the outside into the station, thus displacing the air that is already there. If the system is not operated continuously, it is probably connected to the entrance door or hatch. In this type of system, a switch automatically turns on the blower whenever the door is opened. In either case, the fan system must be carefully maintained and kept in good working condition. Always be sure that the ventilation system is working before you enter a pumping station. If it is not, get help and the proper safety equipment before entering.

Control System

1.41 Most pumping stations are operated on a cyclic basis. That is, the wet well is allowed to fill to a certain level, and then a pump comes on and pumps it down to a set lever. The station cannot be pumped dry, as this would cause the pump to lose its prime. The station probably also has the means to operate a second pump, should the station fill beyond a set point. In some cases, a pump runs continuously and changes speed in response to changes in flow to the wet well. There is also some type of alarm system that signals when there is a problem.

1.42 Most pumping stations have switchgear and accessory panels to provide power for operating and controlling the station components. This panel might be floor-mounted or wall-mounted, and probably will contain the following elements:

- **Main power switch to the station.** For safety reasons, the main power switch is often interlocked with the control panel door. Thus, the operator cannot open the panel door unless the main switch is off.

- **Switches to control each pump.** These switches allow the operator to control the pumps in several ways. For example, you can run the pumps manually, automatically, or shut them off completely. Power switches also are located at each pumping unit so that the operator can start and stop the pumps at the unit without having to go back and forth to the control panel.

- **Lead-follow selector switch.** This device allows the operator to change the sequence in which the pumps start and stop, and also to alternate the pump that comes on first.

- **Gauges, indicators, and recorders.** Some control panels also have these special devices used to monitor pump speed, wet-well level, hours of operation, and sewage flow from the station.

- **Circuit breakers, fuses, and electrical resets.** These electrical protective devices also are located in the switchgear or control panel.

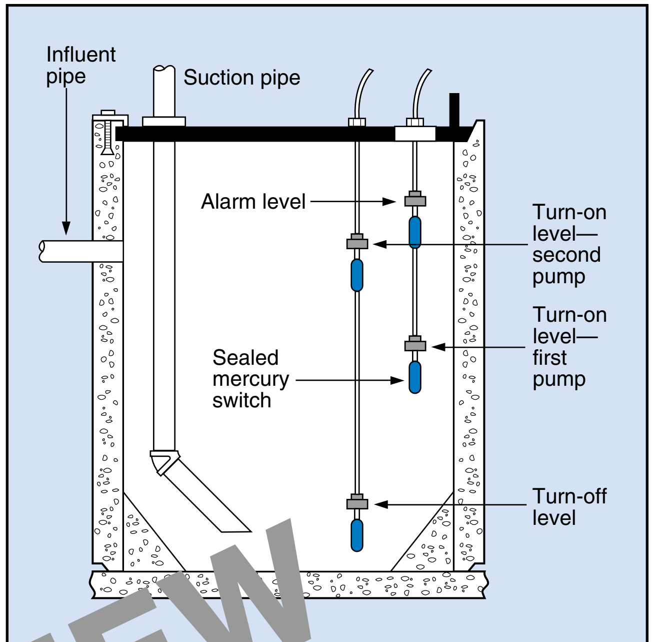
Level Detection

1.43 Water level information is necessary for pump turn-on and shut-off control and to operate the alarm system. Water level information can be sensed in several ways. Three of the most common methods use floats, pneumatic bubblers, and electric probes.

1.44 There are many types of float switches, two of which will be discussed in this Lesson. In the first type, a series of four floats is installed at different levels in a wet well, as shown in Fig. 1-10. The bottom float controls pump shutoff, the next signals the first pump, the next controls the second pump, and the fourth float controls an alarm. Each float is connected to a rod, and the rod to a switch. The switches are connected electrically to the magnetic starter. The water level moves the switches, which in turn control the operation of the pumps.

1.45 The other type of float is the mercury switch bulb. These bulbs are positioned in a well like the float bulbs in Fig. 1-10. Inside the bulb is a mercury switch. When the water level rises to the level of the bulb, the bulb floats sideways, closing the switch and sending a signal to the starter. Figure 1-11 on the following page shows a cutaway view of a mercury switch. As the water level drops, the switch is opened and the motor is shut down.

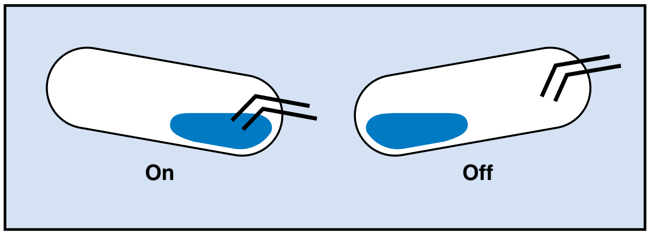
Fig. 1-10. Mercury float switches



1.46 Pneumatic bubbler systems work in a manner similar to float switches. A pipe, usually a 1/4-in. copper or plastic tube, is inserted in the wet well. Air is allowed to bubble through the pipe. As the water level in the wet well increases, the pressure necessary to cause the air to escape increases. This increased air pressure is sensed by a diaphragm. The diaphragm is connected mechanically to a mercury switch. As air pressure builds up, the diaphragm causes the switch to tip and connect, causing the pump to come on. There are usually four mercury switches on the air line to serve the same purpose as float switches.

1.47 Electrical probes can be divided into two groups—active and passive. *Active* probes are made of copper or other metals. Electrodes are set in the probe at various heights, like the float switches. When the water level reaches the bottom electrode, nothing happens. When it reaches the second electrode, an electric circuit is completed between the two electrodes, and the pumps come on. This type of system is

Fig. 1-11. Mercury switch cutaway



prone to maintenance problems due to corrosion of the probe.

1.48 *Passive* resistance probes (sometimes also called *capacitance* probes) usually are encased in plastic and sense the height of the water by detecting a change in the electrical properties of the probe. These changes are a direct reflection of the height of water around the probe.

1.49 Many pumping stations have a feature called *telemetering* that allows flow and level information to be transmitted to a central point. Most stations are checked periodically. Consequently, an operator is not always in the station when something goes wrong. With telemetering, information is transmitted to a central point where someone is on duty at all times. This might be a wastewater treatment facility, or a police or fire station.

1.50 Telemetering is used to transmit only the most critical unusual conditions when an emergency occurs. For example, a flooded wet well, a flooded dry well, a low wet-well level, or a power outage would activate an alarm at a central point. Then the operator who receives the alarm can send someone to check out the problem.

Station Start-Up and Shutdown

1.51 Pumping installation start-up and shutdown are important to reducing overall cost and assuring high efficiency. Before start-up, a new pump or one that has been shut down for an extended length of time should be checked carefully. Make sure that there is water in the wet well and that all debris have been removed. Air should be removed from the volute case by opening the vent. If the pump is supplied with seal water (water to the stuffing box), make sure that the seal water pressure is 10 to 15 psi higher than the design discharge pressure of the pump. All bearings should be lubricated. Turn the shaft by hand to check for free rotation. If the pump is the frame-mounted type, check the alignment between the pump and driver. Start and stop the motor on quick cycle to assure proper direction of rotation.

1.52 If all of these items check out, turn the pump on and check the automatic electrical sequence. The amperage and voltage at the motor should be checked by an electrician and then compared to the nameplate values. With the pump running, check the discharge pressure. Make sure that all valves are completely open and that the check valve moves freely. Check to see that pumps start and stop in the correct sequence, and make sure that levels in the wet well correspond to the control system settings.

1.53 You can check pump flow rate by determining the length of time required to pump down a known portion of the wet well. To obtain a flow rate in gallons per minute, convert this portion to gallons and divide by the elapsed time in minutes. Increased pumping down time can indicate problems, such as pump wear or shaft binding.

1.54 With the pump operating, check for vortexing in the wet well, for leakage at all joints, and for noise and vibration. If the pump contains packing, it should be adjusted to manufacturer's recommendations.

1.55 If a pump is to be shut down for a long period of time, rinse the pump and all lines and valves with fresh water, shut off the seal water, close all valves, drain the pump, and leave the drain plug out. Remove the packing, shut off the power by throwing the breaker or disconnect, tag the control panel, and record the condition.

Station Operation and Maintenance

1.56 Keeping a pumping station operating correctly requires a good preventive maintenance program. To develop this program, record all of the data found on the pump and motor nameplates. Then, using past experience and the manufacturers' data, sort the jobs that need to be done by time interval. List all of the daily tasks on one sheet, the weekly tasks on another, then monthly, bi-monthly, quarterly, yearly, etc. Next, develop a daily checklist for each pumping station. The easiest scheduling system may involve listing the jobs on a calendar.

1.57 Using the daily checklist as a guide, visit each pumping station. Note such items as the height of water in the wet well, the amount of electrical energy used, the condition of the pump packing or seal, the pump discharge pressure, and the hours the pump has run. If the number of hours increases over a short period of time, it may indicate a clogged or worn pump.

1.58 Note any noise or vibration from the pump. Observe if the starter chatters or hums loudly when engaged. Check the emergency power supply system. If you smell burnt insulation, shut down the pump and notify an electrician.

1.59 Watch the station go through one complete cycle. Shut off the lead pump and let the level in the wet well rise to check that the follow pump comes on. Also, alternate the lead and follow pumps.

1.60 Take voltage and amperage readings monthly and compare them to nameplate data and past records. Pump pressure can be noted at the same time. These readings can be used to identify pump problems, such as worn impellers, plugged lines, and bad bearings. At least quarterly, note the bearing temperature and motor rpm.

1.61 Shut off the pumps periodically to check the flooded wet-well alarm. Then pump down the wet well and hose accumulated solids from the wet-well floor to the pump suction. This will reduce odors and also will test the low wet-well level alarm. You also might shut off the main power supply for a moment to check the power failure alarm.

1.62 Flush the sump pump with fresh water to flush out sewage that leaks from the packing glands on the main pumps. This will prevent odors in the dry well and assure that the sump pump operates properly. Also test the flooded dry-well alarm at this time. When checking any of the alarms, be sure to let the operator at the location where the alarms are received know what you are doing.

Safety Considerations

1.63 Most states require that you be a licensed electrician before you perform any electrical maintenance. All entry into the electrical panel should be made in the presence of another person. The person doing the work should not wear rings, watches, bracelets, or loose clothing. The worker should stand on an approved mat and should have only one hand in the panel at a time.

1.64 When working on a pump, you must be sure that electric power is turned off and locked out to keep the pump from starting accidentally. Do not wear loose clothing or jewelry when working around moving parts. Also use caution if you have long hair or a beard. Guards should be placed over couplings and shafts to help avoid accidents.

1.65 The interior of a pumping station may contain toxic or flammable gases. A properly operating ventilation system is essential, especially in underground pumping stations. Before entering any confined space, such as a wet well, use an approved meter to check for the presence of explosive gases and the absence of oxygen.

1.66 Good housekeeping is essential for avoiding accidents. Be sure to clean up water, mud, and oil that may be on the floor. Do not leave rags on the floor. Keep lighting fixtures clean to improve visibility. Be sure that chains and guard rails are in place around pits, wells, and floor openings. Use the buddy system when working near wells, and be sure that adequate rescue equipment is on hand.

1-9. When operated under damp conditions, pumps require lubrication ________ frequently than usual.	1-9. MORE Ref: 1.25
1-10. The two sections of a pump's piping system are called ________ and ________ piping.	1-10. SUCTION DISCHARGE Ref: 1.35
1-11. Why is a gate valve a good isolation valve?	1-11. BECAUSE IT LEAVES AN UNRESTRICTED PATH WHEN OPEN Ref: 1.38
1-12. The pumps in a lift station turn on and off in response to ________.	1-12. WATER LEVEL Ref: 1.43
1-13. When a mercury switch bulb floats sideways, the switch is ________.	1-13. CLOSED Ref: 1.45
1-14. In a pneumatic bubbler system, air pressure changes are sensed by a(n) ________.	1-14. DIAPHRAGM Ref: 1.46
1-15. The transmission of flow and level information from a pumping station to a central point is called ________.	1-15. TELEMETERING Ref: 1.49
1-16. When working on a pump, you should make sure that electric power to the unit is turned off and ________.	1-16. LOCKED OUT Ref: 1.64

Answer the following questions by marking an "X" in the box next to the best answer.

1-1. The pump is submerged in a ________ pumping station.

- ☐ a. combined
- ☐ b. dry-well
- ☐ c. pneumatic ejector
- ☐ d. wet-well

1-2. Flow into and out of a pneumatic ejector is controlled by

- ☐ a. flap valves
- ☐ b. gravity
- ☐ c. mercury switches
- ☐ d. propellers

1-3. The type of pump used most commonly in lift stations is the ________ pump.

- ☐ a. axial-flow
- ☐ b. centrifugal
- ☐ c. pneumatic ejector
- ☐ d. vortex

1-4. The component that surrounds a pump impeller is the

- ☐ a. frame
- ☐ b. housing
- ☐ c. stuffing box
- ☐ d. volute case

1-5. The purpose of a shaft sleeve is to

- ☐ a. lengthen the pump shaft
- ☐ b. protect the pump case
- ☐ c. protect the pump shaft
- ☐ d. reduce leakage

1-6. When replacing pump packing, you must

- ☐ a. cut the packing in individual rings
- ☐ b. make sure that the ends overlap
- ☐ c. make sure that there is no leakage
- ☐ d. use a size larger than recommended

1-7. If you replace a pump impeller with one of a larger size, the

- ☐ a. energy transferred to the fluid will be reduced
- ☐ b. motor will operate more efficiently
- ☐ c. pump pressure will be reduced
- ☐ d. pump will draw more current

1-8. The best type of isolation valve to use on the suction side of a pump is a ________ valve.

- ☐ a. butterfly
- ☐ b. flap
- ☐ c. gate
- ☐ d. globe

1-9. What happens when air enters the volute case of a pump?

- ☐ a. A vacuum is created
- ☐ b. The pump becomes primed
- ☐ c. The pump runs backward
- ☐ d. The pump will not function

1-10. A pneumatic bubbler system senses changes in level by sensing changes in

- ☐ a. air pressure
- ☐ b. bubble size
- ☐ c. buoyancy
- ☐ d. electrical resistance

SUMMARY

Collection systems, also known as sewers, consist of three elements—piping, manholes, and pumping stations. Pumping stations lift the sewage so that it can flow to treatment facilities. The three types of pumping stations are the wet well, the dry well, and the pneumatic ejector.

Wet-well and dry-well station components include a pump (usually centrifugal), a drainage system, the pump drive unit, a backup power system, the piping system, a ventilation system, and a control system.

Always maintain pumps according to the manufacturer's instructions. Make sure that piping to and from the pump remains unobstructed. Before entering a pumping station, make sure that the ventilation system is functioning properly. Check the control and level detection system periodically. As always, observe good safety practices when working in pumping stations.

Answers to Self-Check Quiz

1-1. d. Wet-well. Ref: 1.06

1-2. a. Flap valves. Ref: 1.07

1-3. b. Centrifugal. Ref: 1.11

1-4. d. Volute case. Ref: 1.14

1-5. c. Protect the pump shaft. Ref: 1.17

1-6. a. Cut the packing in individual rings. Ref: 1.26

1-7. d. Pump will draw more current. Ref: 1.30

1-8. c. Gate. Ref: 1.36

1-9. d. The pump will not function. Ref: 1.36

1-10. a. Air pressure. Ref: 1.46

Contributions from the following source are appreciated:

Figure 1-4. Clow Corp. Pump Div., Yeomans Products
Figure 1-7. Berkeley Pump Company
Figure 1-8. Berkeley Pump Company