

Wastewater Treatment Plant Operator Certification Training



Module 24: Wastewater Collection Systems Part II Revised 2020

This course includes content developed by the Pennsylvania Department of Environmental Protection (Pa. DEP) in cooperation with the following contractors, subcontractors, or grantees:

The Pennsylvania State Association of Township Supervisors (PSATS)
Gannett Fleming, Inc.
Dering Consulting Group
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Topical Outline

Unit 1 – Overview of Pumping Stations

- I. Types of Pumping Stations
 - A. Wet Well/Dry Well
 - B. Submersible
 - C. Vacuum
- II. Regulatory Requirements
 - A. Standards
 - B. Permitting
- III. Components
 - A. Wet Wells
 - B. Dry Wells
 - C. Electrical Systems
 - D. Controls
 - E. Pumps/Motors
 - F. Valves

Unit 2 – Management and Operations of Pumping Stations

- I. Policy and Requirements
 - A. Permitting
 - B. Annual Reporting – Chapter 94
- II. Operation and Maintenance
 - A. Tasks
 - B. Scheduling
 - C. Recordkeeping
 - D. Equipment Maintenance

Unit 3 – Safety

- I. Safety Procedures
 - A. Traffic Control
 - B. Confined Space Entry – Manholes
 - C. Excavations
 - D. Electrical
- II. Collection System Hazards
 - a. Accidents and Injuries

Unit 1 – Overview of Pumping Stations

Learning Objectives

- List three types of pumping stations describe how each operates and explain the ideal conditions needed for each station to operate properly.
- Explain the standards and permitting requirements that apply to pumping stations.
- List and describe the components of pumping stations.

Wet Well/Dry Well

- ✓ In the wet well/dry well pumping station the dry well is separated from the wet well.
- ✓ The pumps, motors, electrical control and auxiliary equipment are located in the dry well. These components will be explained more fully later in this unit.
- ✓ This pumping station is typically used for high flows because it has a higher initial cost than a submersible station.

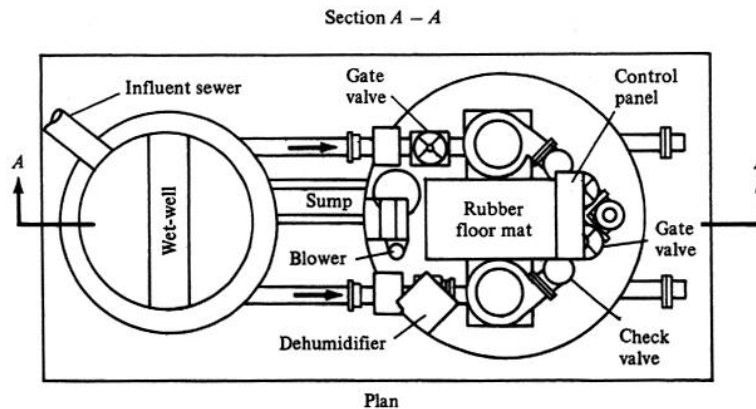
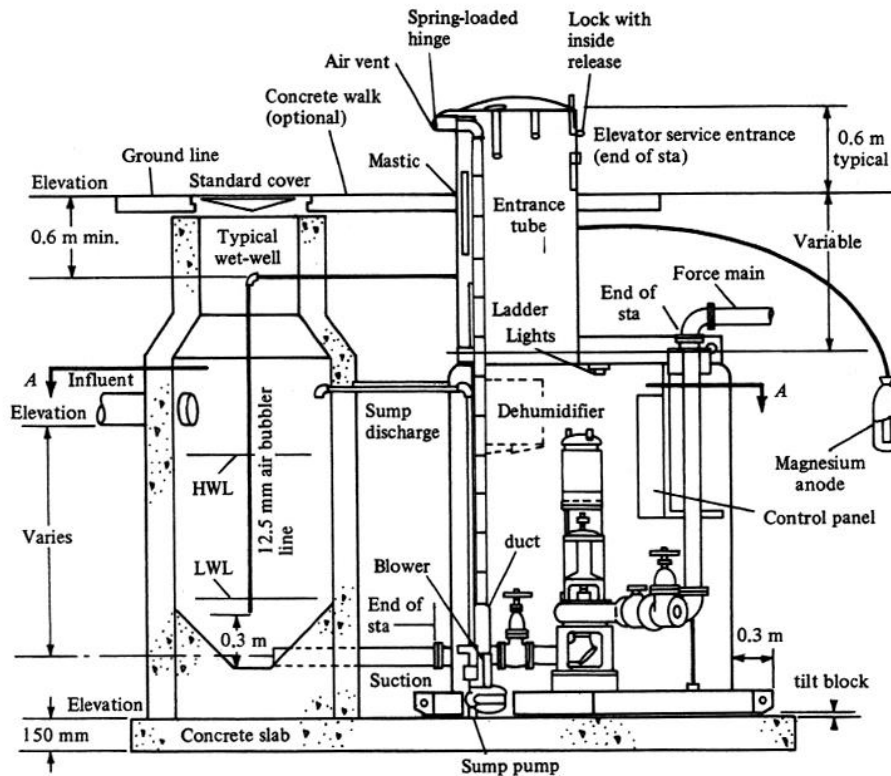


Figure 1.1 A Wet Well/Dry Well¹

Submersible

- ✓ A submersible pumping station consists of submersible pumps placed in a wet well.
- ✓ It is typically used when there are low flows and high heads (pumping against large changes in elevations).

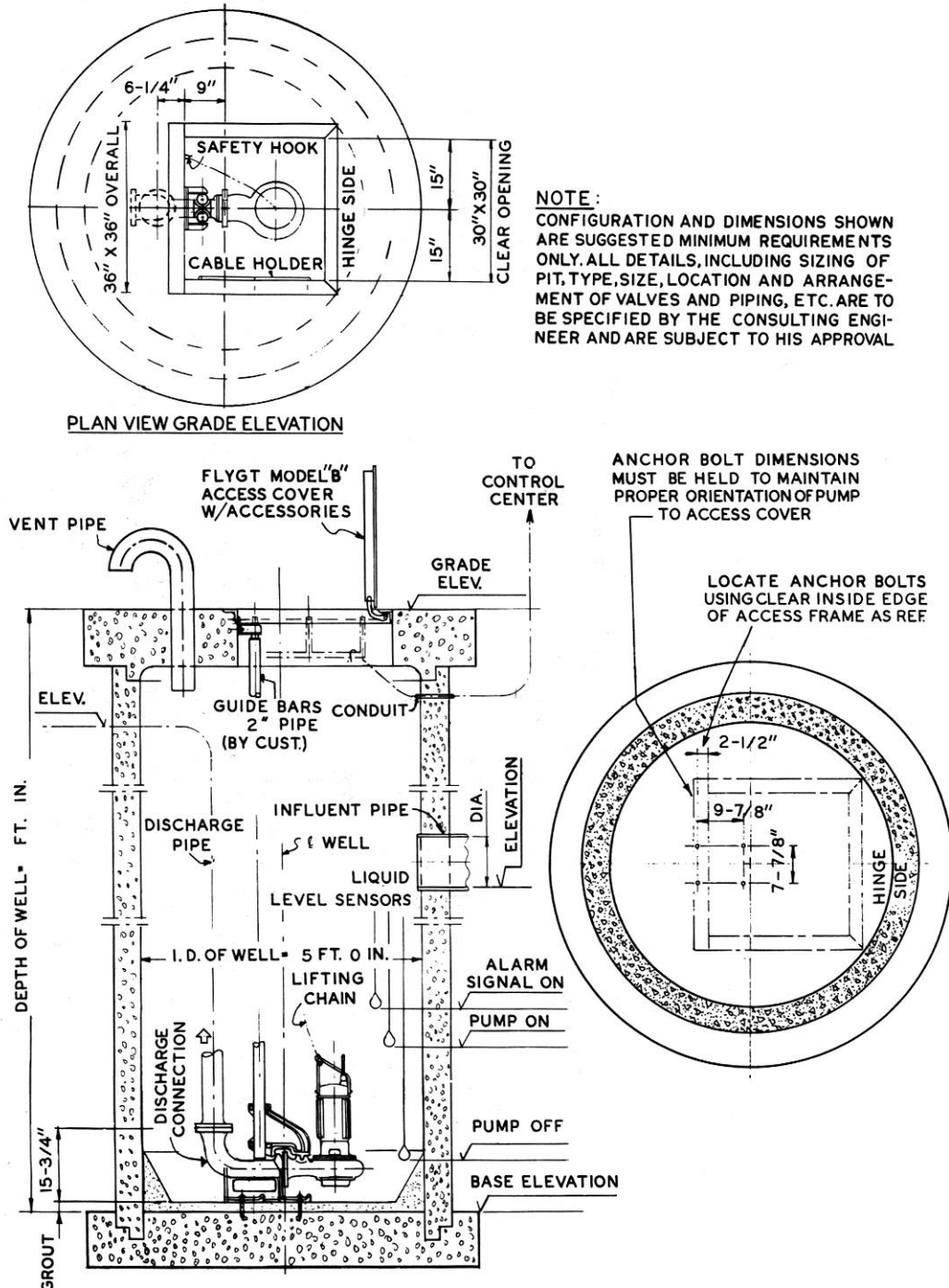


Figure 1.2 A Submersible Pumping Station²

Vacuum

- ✓ Vacuum pumping stations are not typically found in Pennsylvania.
- ✓ The station is considered an alternative type of system and additional information can be found in the EPA's *Alternative Wastewater Collection Systems Manual*.

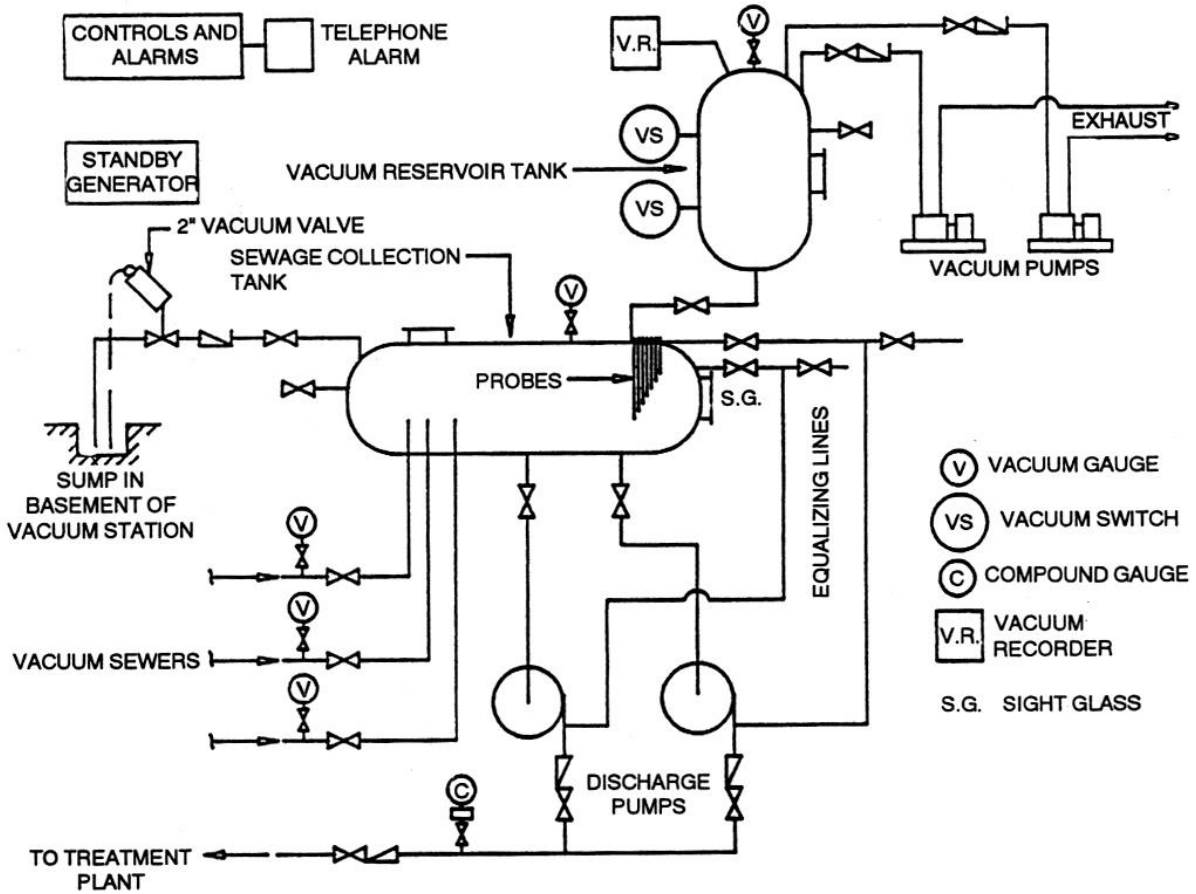


Figure 1.3 Vacuum Pumping Station³

Standards

Information regarding the standards for pumping stations in Pennsylvania can be found in the PA DEP *Domestic Wastewater Facilities Manual*.

- ✓ General standards include the following:
 - Wastewater pumping stations shall remain fully operational during a 25-year storm and shall be protected from physical damage during a 100-year storm.
 - The pumping station should be readily accessible by maintenance vehicles.
 - Design must include special consideration for grit removal if wastewater is pumped prior to grit removal.
 - Adequate pumping capacity must be provided when an existing pumping station is renovated.
 - An alarm system should be provided at all pumping stations.
 - Typical alarm situations at a pump station may include:
 - Power failures
 - Pump failures
 - High wet well levels
 - For emergency operation, pumping stations should be designed to prevent or minimize the bypass of water.
 - Each pumping station should have a complete set of operational instructions.

- ✓ Wet and Dry Well Pumping Station Specific Standards are provided for the following items:
 - Structures.
 - Pumps and pneumatic ejectors.
 - Controls.
 - Valves.
 - Wet wells.
 - Ventilation.

- ✓ Suction Lift Pump Stations Specific Standards are provided for the following items:
 - Self-priming pumps.
 - Vacuum priming pumps.

- ✓ Submersible Pump Stations Specific Standards are provided for the following items:
 - Structures.
 - Pumps and pneumatic ejectors.
 - Controls.
 - Valves.
 - Wet wells.
 - Ventilation.

Permitting

To construct and modify a pumping station, a Water Quality Management Part II Permit Sewer Extensions and Pumping Stations permit must be obtained.

Wet Wells

- ✓ A wet well stores wastewater prior to pumping, provides submergence over pump suction and may house appurtenant equipment to protect pumps.
- ✓ The size of the wet well affects the operating of the station. If a wet well is too small, excessive starting and stopping of the motors will occur, resulting in premature failure. If the wet well is too large, solids will tend to settle on the bottom, blocking the pump suction line and leading to the generation of hydrogen sulfide and methane.
- ✓ The formula for computing the required wet well storage is:

$$V = \frac{(t)(Q)}{4}$$

Where:

V = storage volume (gal)

t = required time between starts (min)

Q = pump discharge capacity (gpm)

The t value should typically be 10 minutes to minimize odors and prevent septicity caused by anaerobic conditions.

- ✓ The pump operates between the high and low water levels. The high level is set below the invert of the gravity line entering the wet well to prevent wastewater from backing up in the gravity line. The low water level is set by the centerline of the pump impeller to ensure that the pump inlet remains submerged.
- ✓ The atmosphere in a wet well may be corrosive. Therefore, access hatches, steps and hardware should be built with non-corrosive material (i.e. fiberglass, aluminum, stainless steel). Aluminum in contact with concrete in a wet well will corrode if it is not coated with a protective covering.
- ✓ Since a wet well atmosphere may contain explosive or flammable gases, all electrical equipment in the wet well must be either explosion-proof or be rated as intrinsically safe (by its very nature safe).
- ✓ Bar racks and screening devices may be added in a wet well to protect the pumps from debris. If these devices are installed, additional maintenance will be required to remove the captured screenings.

Dry Wells

- ✓ The dry well is the portion of the dry well/wet well pumping station that houses the necessary equipment required to pump the wastewater. The dry well is so named because it is isolated from the incoming wastewater.

Electrical Systems

✓ The typical electrical service to pumping stations is three-phase utility power.

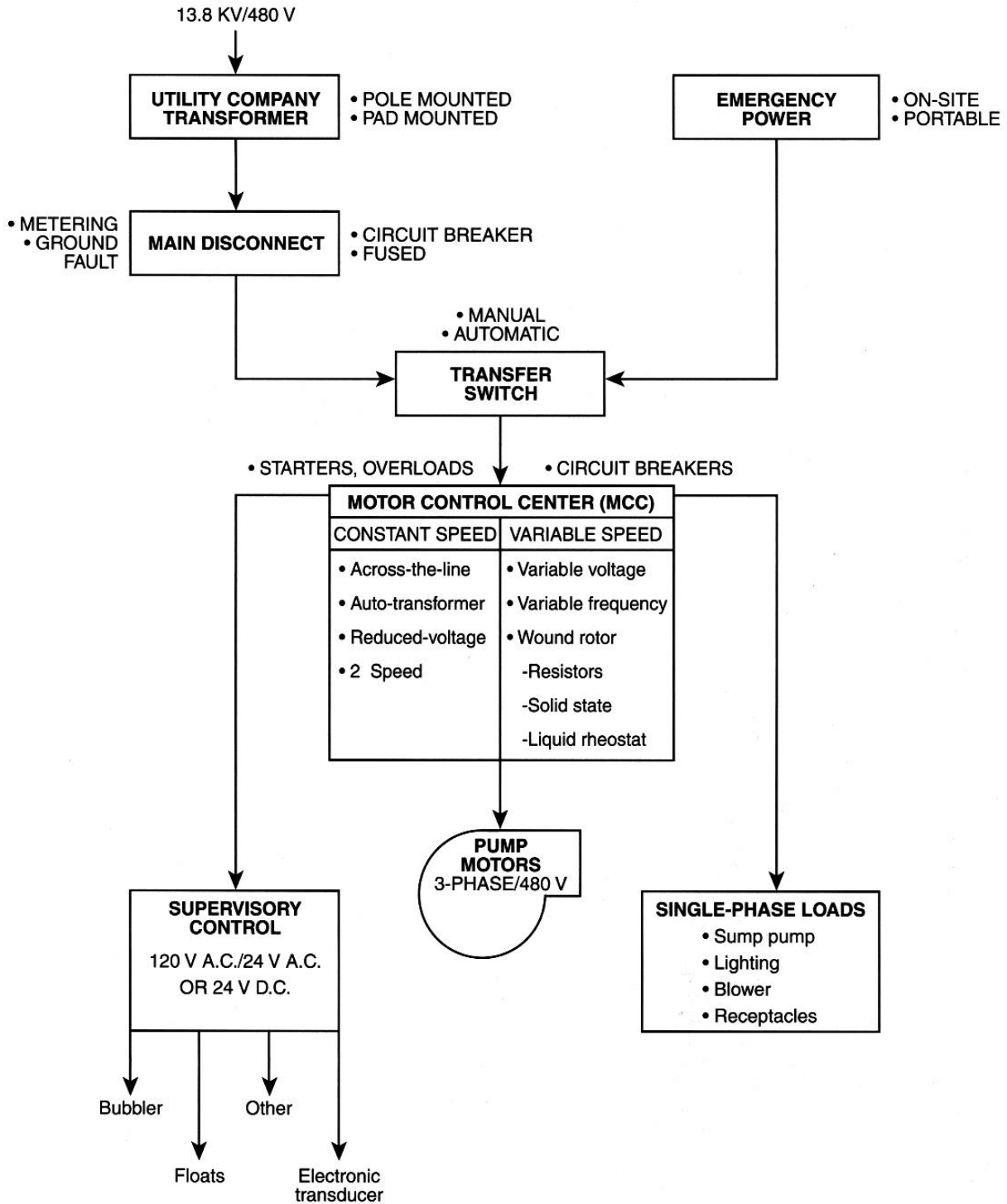


Figure 1.4 A Typical Pump Station Electrical System ⁴

- ✓ The typical electrical system consists of the following components:
 - Pole-mounted or pad-mounted power transformers through which the utility company supplies power. The utility company typically installs a watt/hour meter to determine demand at the pumping station.
 - A main disconnect switch that isolates the entire electrical system.
 - A transfer switch which is used to switch to an emergency generator when the utility power source is lost.
 - The Motor Control Center (MCC), also referred to as the main panel, which houses the controls for all motors and electrical equipment within the station.
 - Variable-speed motors and drives are often used in order to pace the motor speed to match the incoming flow. The types of variable-speed systems typically used are:
 - Variable voltage
 - Variable frequency drives (VFDs)
 - Wound-rotor motor
 - Supervisory controls that control the operation of the pump motors. Most new supervisory controls contain programmable logic controllers (PLCs), which use microprocessor-based control unit input modules and output modules to automatically control the sequencing of pump motors and other equipment in the station.

Controls

- ✓ Controls tell pumps when to operate based on the level of wastewater to be pumped out of the wet well.
- ✓ Primary controls measure the level of water in a wet well. Typical primary controls include float controllers, level transducers, ultrasonic level detectors and air bubblers.
- ✓ Secondary controls are used to convert the measurement from the primary control to a mechanical or electrical signal for a pump to start, stop or change speeds.

Float Controllers

- ✓ Float controllers are one of the oldest methods used to start and stop pumps based on the level of wastewater in the wet well.
- ✓ The float may be any of the following:
 - A four- to eight-inch diameter copper or stainless-steel ball.
 - A six- to twelve-inch diameter copper stainless steel or ceramic material flat plate that is several inches thick.

- A six- to ten-inch diameter glass, stainless steel or ceramic material cylinder that is six- to ten-inches in depth.
- An old brown jug partially filled with sand or lead shot to provide stability.
- ✓ The device floats on the water surface and as the water surface rises, the float rises; as the water level is pumped down, the float is lowered with the water.
- ✓ The float is attached by steel rods, steel tapes, cables or ropes that transmit the float level to a recording or signaling device.

Level Transducers

- ✓ A level transducer consists of a level sensor that is mounted with a sensor below the water surface. A transducer converts one form of energy into another.
- ✓ The transducer is a pressure transducer and is continually submerged. A change in the static head in the wet well creates a pressure that is sensed by the flexible membrane at the bottom of the transducer. The pressure is converted to an electrical signal that is transmitted to the control system.

Ultrasonic Level Detectors

- ✓ An ultrasonic level detector consists of a transducer mounted above the highest water level in the wet well.
- ✓ The ultrasonic transducer transmits a pulse that is reflected by the surface of the water. The time elapsed between sending the pulse and receiving the pulse determines the level of water in the wet well.

Air Bubblers

- ✓ Air bubblers provide constant, low-volume, low-pressure air through a vertically mounted pipe in the wet well.
- ✓ The amount of water in the wet well is determined by the force required to displace the water in the pipe.

Pumps/Motors

Pumps and motors are the major pieces of equipment in the station. Pumps are either kinetic or positive displacement pumps. Kinetic pumps, which include centrifugal pumps, produce high-velocity kinetic energy and convert it to pressure. Positive displacement pumps produce pressure by applying force directly to the fluid.

Centrifugal Pumps

Centrifugal pumps are the most common type of pump found in wastewater pumping stations. The following are the components of the centrifugal pump:

- ✓ The keyway is located in the top of the shaft and this permits removal of the entire pump power frame and rotating assembly without disturbing the suction and discharge piping or pump base.
- ✓ The jacksaw for impeller adjustment is provided to adjust clearances from the outside of the pump.
- ✓ In double row thrust bearings, the upper bearing accommodates upward and downward vertical thrusts along the axis of the shaft and the lower bearing accommodates perpendicular (side-ways) thrusts.
- ✓ The stuffing box provides isolation between the liquid end of the pump and the atmosphere.
- ✓ The shaft sleeve permits replacement of the sleeve rather than the shaft when wear occurs.
- ✓ The shaft drives the impeller.
- ✓ The impeller rotates and transfers energy to the fluid being pumped.

Positive Displacement Pumps

Positive displacement pumps are typically used at wastewater treatment plants and are uncommon in pumping stations. A pneumatic ejector is a positive displacement pump that may be used for small flows that are less than the capacity of the small centrifugal pump.

A typical pneumatic ejector consists of a receiver (pot), air compressor, controls and piping.

General Overview of Pump Hydraulics

An understanding of basic pump hydraulics is necessary to understand how the pump operates and to troubleshoot when problems may occur.



Head is an indication of the pressure of the force exerted by water.



Pressure head is the amount of energy in water due to water pressure.



Velocity head is the amount of energy in water due to velocity.



Elevation head is the amount of energy in water due to elevation.



Friction head loss is the energy that water loses from friction while moving through the pipeline and the various fittings.



Total dynamic head (TDH) is the amount of energy that a pump must develop to move a liquid.



Break horsepower (BHP) is a measure of the power required by a centrifugal pump to discharge a given amount of water against a known TDH.



Cavitation occurs in a pump when the absolute pressure at the pump inlet drops below the vapor pressure of the water being pumped. Cavitation causes severe vibration, which creates a loss in the pump efficiency and capacity and physical damage to pump.



Net Positive Suction Head (NPSH) is the total absolute suction head at the inlet of the pump minus the vapor pressure of the water. Cavitation will occur if the NPSH at the inlet is less than the minimum NPSH required by the pump.

Valves

Valves are necessary at pumping stations to permit the proper flow of fluids and permit maintenance to occur.

Gate Valves

Gate valves are located immediately before and after pumps to isolate the pump from the wet well and force main during maintenance. The valve should be exercised frequently to keep the threads operational.

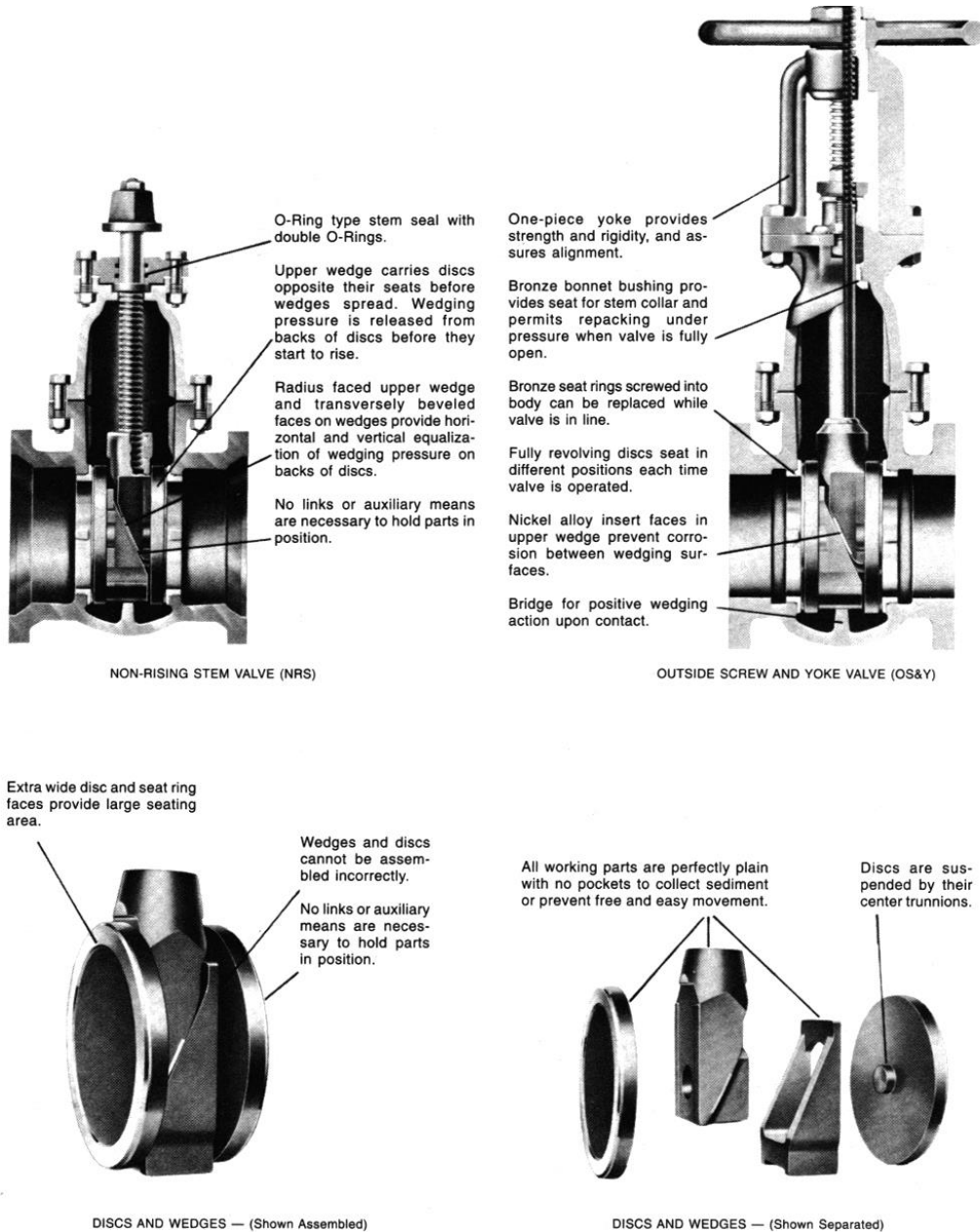


Figure 1.5 Gate Valves⁵

Plug Valves

Plug valves may also be used to isolate the pump from the wet well and the force main for maintenance purposes. Plug valves are less susceptible to clogging.

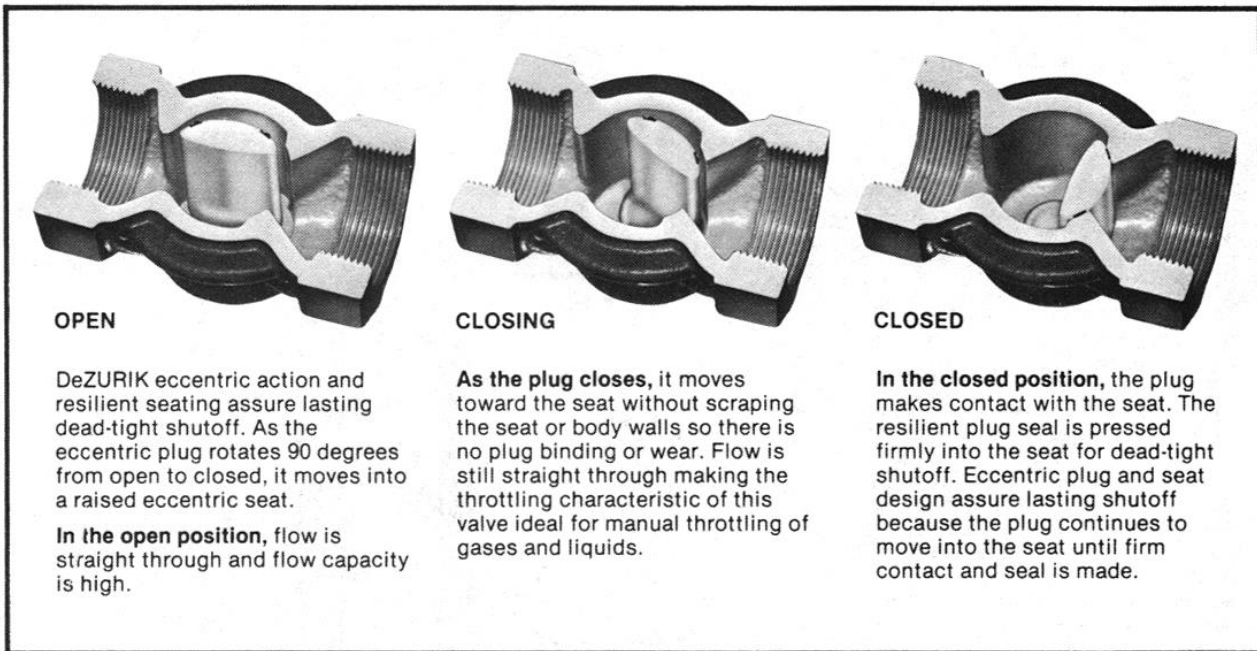


Figure 1.6 Opening and Closing of a Plug Valve⁶

1. Corrosion resistant plug
 Plug materials resist corrosion and prolong seat life. Available materials are as follows:

- Bronze (½"-2" only)
- Electroless nickel plated cast iron (2½"-4" valves only).

2. Double-seal for tight shutoff and safety A resilient seal molded into a groove in the plug face assures dead-tight shutoff on liquids and gases without the use of sealing lubricants. When the plug is closed, the resilient seal is compressed against the seat. The metal on the plug face also makes contact with the metal seat to provide a second seal for safety. Gas industry fire tests showed that this second metal seal provides nearly bubble-tight shutoff with the resilient seal burned away.

3. O-Ring stem seal
 A variety of stem seal materials provides maintenance-free sealing that matches valve performance and assures long life and reliability.

4. Corrosion resistant bearings
 Permanently lubricated bearings in the upper and lower plug journals resist corrosion and assure easy operation without lubrication. And, operation is just as easy whether the valve is operated once a day or once a year.

5. Corrosion resistant seal
 A plastic seat coating provides extra corrosion resistance to minimize plug wear.

6. Meets ANSI 125 lb. standard
 Body walls and end connections conform to all applicable ANSI 125 pound standards. Valves meet MSS standards in ½" and ¾" sizes where ANSI standards are not available.

7. Choice of end connections
 A complete choice of end connections includes screwed, flanged, Dresser and Victaulic. A complete listing of availability for each valve size and FIG number is shown in the ordering section.

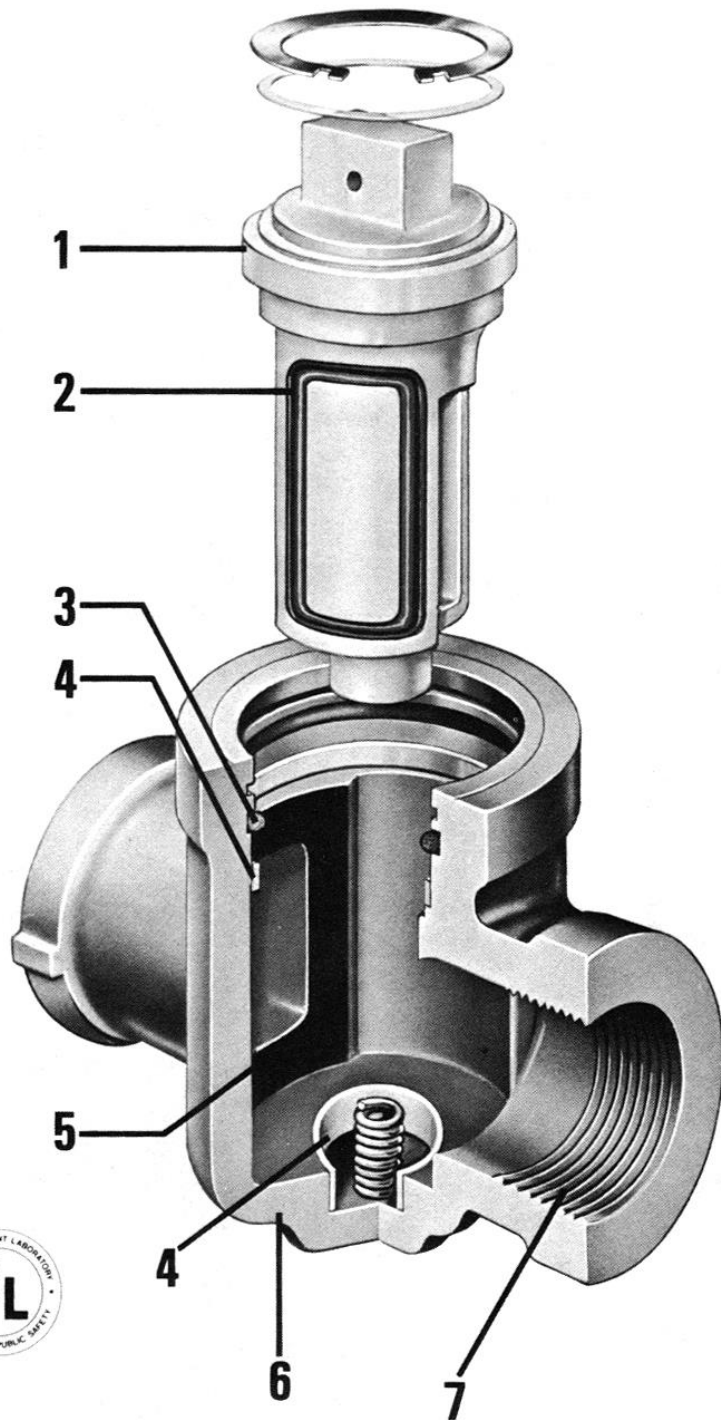


Figure 1.7 A Plug Valve ⁷

Check Valves

Check valves are typically installed in the discharge of each pump to prevent the force main from draining back into the wet well.

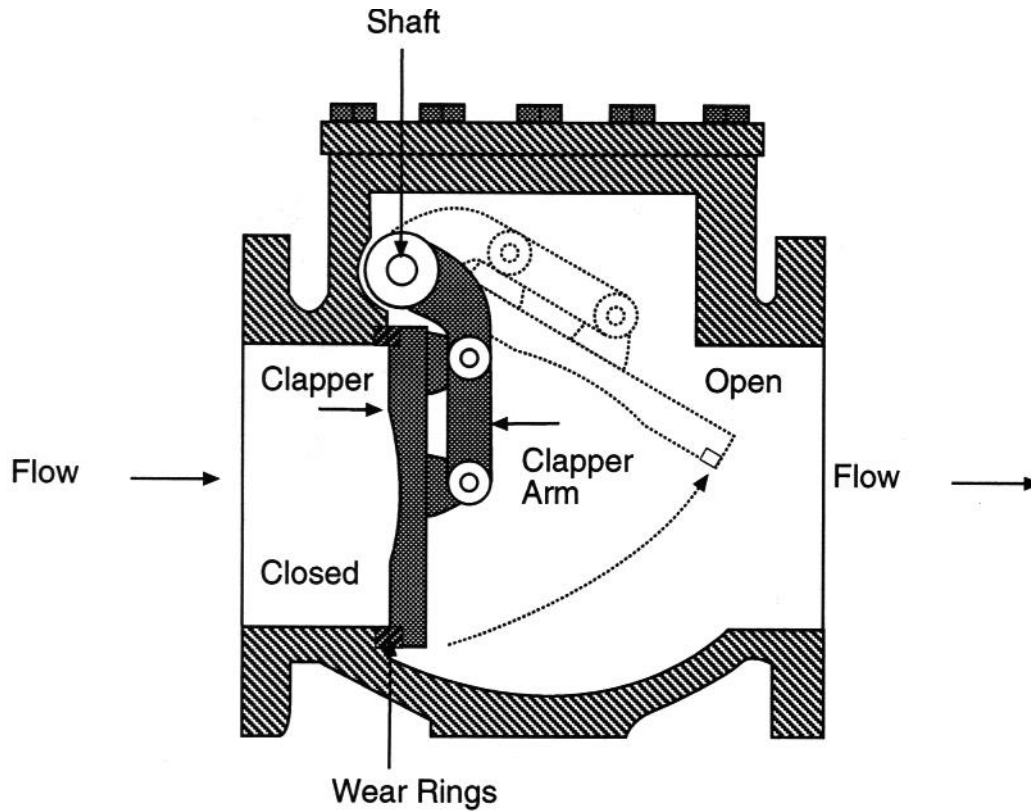


Figure 1.8 A Check Valve⁸



Unit 1 Key Points – Overview of Pumping Stations

- There are 3 types of pumping stations: the wet well/dry well, the submersible pumping station and the vacuum pumping station.
- In the wet well/dry well pumping station the dry well is separated from the wet well and is typically used for high flows.
- The submersible pumping station is a pumping station in which the pumps are located underground in the wet well and is typically used when there are low flows and high heads.
- Vacuum pumping stations are typically used in the southern U.S. in flat coastal areas.
- Information regarding the standards for pumping stations in Pennsylvania can be found in the PA DEP *Domestic Wastewater Facilities Manual*.
- A Part II Permit Sewer Extensions and Pumping Stations permit must be obtained to construct or modify a pump station.
- A wet well stores wastewater prior to pumping, provides submergence over pump suction and may house appurtenant equipment to protect pumps.
- The formula for computing the required wet well storage is:

$$V = \frac{(t)(Q)}{4}$$

- The dry well is the portion of the dry well/wet well pumping station that houses the necessary equipment required to pump the wastewater. The dry well is so named because it is isolated from the incoming wastewater.
- The typical electrical service to pumping stations is three-phase utility power.
- There are four types of flow controls: float controllers, level transducers, ultrasonic level detectors and air bubblers
- There are mainly two types of pumps utilized in pump stations: centrifugal pumps and positive displacement pumps
- Kinetic pumps, which include centrifugal pumps, produce high-velocity kinetic energy and convert it to pressure.
- Positive displacement pumps produce pressure by applying force directly to the fluid.
- There are three types of valves: gate valves, plug valves and check valves.



Exercise

1. List three types of pumping stations and explain when each is used.

- a. _____

- b. _____

- c. _____

2. What is the difference between a centrifugal pump and a positive displacement pump?

3. List three types of valves and explain when each is used.

- a. _____

- b. _____

- c. _____

¹ George Tchobanoglous, "Pumping Stations", in *Wastewater Engineering Collection and Pumping of Wastewater*, (New York, NY: McGraw-Hill, Inc., 1981), p. 347.

² Manuel Munoz and John Brady, "Lift Stations", in *Operation and Maintenance of Wastewater Collection Systems: A Field Study Training Program, Vol II*, (Sacramento California: California State University, Sacramento Foundation, 1998), p. 11.

³ William C. Bowne, Richard C. Naret and Richard J. Otis, "Vacuum Sewer Systems" in *Alternative Wastewater Collection Systems EPA/625/1-91/024*, (Published by U.S. Environmental Protection Agency, 1991), p. 100.

⁴ Munoz and Brady, p. 32.

⁵ Munoz and Brady, p. 78.

⁶ Munoz and Brady, p. 82.

⁷ Munoz and Brady, p. 81.

⁸ Munoz and Brady, p. 82.

Additional Resources

PA DEP Domestic Wastewater Facilities Manual

Unit 2 – Management and Operations of Pumping Stations

Learning Objectives

- List and explain three major policies and requirements associated with the management and operation of a collection system.
- List and explain the tasks, scheduling, recordkeeping and equipment maintenance requirements associated with the operation and maintenance of a wastewater collection system.

Permitting

- ✓ There are currently no NPDES permitting requirements for a community that only has a pumping station and collection system.
 - A National Pollutant Discharge Elimination System (NPDES) permit may be required in the future.
- ✓ Currently, only communities with a treatment facility must have a NPDES permit that must be renewed every five years.

Annual Reporting – Chapter 94

- ✓ Annual reporting requirements are described in the Pennsylvania Code Title 25 Environmental Protection § 94.12. Annual Report.
- ✓ The treatment plant permittee needs to submit a complete and accurate wasteload management report to the Pennsylvania Department of Environmental Protection by March 31 of each year. The report requires the following:
 - Information about the condition of pumping stations.
 - A comparison of the maximum pumping rate and the present maximum flows and the projected maximum 2-year flows at each station. If the projected 2-year flows are shown to overload the station, the permittee must propose a plan to reduce or eliminate the projected overload condition.

Tasks

The following tasks should be completed at the pumping station to ensure the pumping station operates continuously and efficiently.

Routine Maintenance

- ✓ Routine preventative maintenance should be performed at pumping stations to ensure that pumping stations do not prematurely fail due to neglect.
- ✓ Typical routine maintenance items include the following:
 - Lubricate and change oil.
 - Inspect for vibration/noises that might indicate loss, failure or other problem.
 - Exercise valves.
 - Inspect the wet well and note the condition.
 - Check flow and electrical switches weekly

Emergency Response

- ✓ When an alarm signals at a pumping station, an operator must go to the station to determine the cause and attempt to restore function to the station.

Draw Down Tests

- ✓ Draw down tests should be performed on a regular basis to determine the effective capacity of the pumps.

Scheduling

Maintenance tasks should be scheduled as recommended by the equipment manufacturers.

- ✓ A scheduling program at a pumping station requires considering the following three factors:
 - Equipment manufacturer maintenance and overhaul recommendations.
 - Pumping station requirements based on the design and location of the station.
 - Knowledge gained from experience with pumping stations

Recordkeeping

Records are an important part of a maintenance program for a sewer system.

- ✓ Every pumping station should have a sign-in log to document who was at the station and time of their arrival and departure. The log sheet creates a higher reliability that maintenance is being performed and provides a means of contacting the appropriate person when corrective action is required.

- ✓ Every pumping station should have a loose-leaf binder that contains the information listed below. The binder should be maintained in the owner's office to ensure that it is not lost or damaged at the station.
 - Station identification.
 - A map showing the location of the station in relation to the force main, force main discharge point and other underground utilities.
 - A brief description of the station.
 - Safety instructions.
 - Equipment data sheets.
 - Action to be taken when an emergency occurs.
 - Preventative maintenance schedule.

- ✓ Additional records that should be kept include the following:
 - Cost reports stating the annual operation and maintenance costs.
 - Station identification numbers.
 - Preventive maintenance schedule
 - Unscheduled work order requests.
 - Modifications made to the pumping station or the force main.
 - Written reports providing details of unusual conditions or repairs to the pumping station.
 - Operational data.

Personnel

- ✓ A confidential and up-to-date file should be maintained for each employee. The file should include:
 - Personal information such as age, blood type, inoculations, medical history and list of dependents in case of an accident or injury.
 - Work-related information including date of hire, pay, work history, commendations, disciplinary actions, certifications and training courses attended.

Equipment

The following information should be maintained:

- ✓ Equipment inventory and depreciation.
- ✓ Preventative maintenance performed on a piece of equipment.
- ✓ Total use of a piece of equipment.

Sanitary Sewer Lines

Records for sanitary sewer lines should include:

- ✓ Main line inventory.
- ✓ Maintenance records.
- ✓ Televising records.
- ✓ Stoppage reports.

Service Laterals

- ✓ Lateral inventory, location and maintenance records should be kept.

Training

- ✓ Records should include on-the-job and formal training and certifications held by employees.

Safety

- ✓ Records should include a safety policy statement and on-going safety training program for employees.

Accidents

- ✓ A record of every accident and complete accident reports should be maintained.

Equipment Maintenance

Equipment must be properly maintained to minimize premature failing.

Electrical

- ✓ Electrical equipment should be inspected and maintained at least annually.
- ✓ Inspection should include an examination, replacement of worn and expendable parts and operational checks and tests.

Motors

- ✓ Motors should operate for years without major maintenance if operated in a clean, dry space within the manufacturers' specified load and operating characteristics.
- ✓ Each motor should be inspected to ensure that it is operating within manufacturers specifications.
- ✓ Routine maintenance includes lubrication. Care must be taken because excessive greasing can be as damaging to the motor bearings as undergreasing.
- ✓ When an electric motor fails, there may be a variety of causes. Phase failure is a very common electrical fault experienced by three-phase motors. A multimeter set to AC voltage is capable of measuring phase failures and is capable of providing diagnostic information for all kinds of motors.

Pumps

- ✓ Guidelines for routine pump maintenance should be obtained from the pump manufacturer to ensure that all necessary maintenance is performed.
- ✓ At routine maintenance visits, the operator should listen to the pump for cavitation noises and any other noises or vibrations that might indicate bearing failure.
- ✓ The pump impellers should be inspected for wear on a regular basis and adjusted to maintain proper tolerance.
- ✓ Flow and electrical switches should be checked weekly to make sure of appropriate response to flows within the pump station.

Compressors



A **compressor** is a device used to increase the pressure of air or gas.

- ✓ Maintenance of a compressor involves inspecting the suction filter regularly and cleaning or replacing filters every 3 to 6 months.
- ✓ The compressor bearings must be lubricated and not overfilled.
- ✓ The cylinder or casing fins should be cleaned weekly and safety valves should be tested weekly.
- ✓ Condensate from the air receiver should be drained daily.
- ✓ The belt tension should be inspected to ensure proper tension.
- ✓ The compressor should be cleaned thoroughly monthly.

Lubrication

- ✓ Lubrication reduces friction between two surfaces and is one of the most important factors in successfully maintaining equipment.
- ✓ A lubrication schedule should be developed to ensure that all equipment that requires lubrication receives the correct lubrication at the time frame required.
- ✓ Most lubricants are combustible, so they should not be stored near an open flame.
- ✓ Lubricants must be carefully installed and the equipment should be inspected following installation to ensure a proper level.



Key Points

- Currently, there are no permitting requirements for a community that only has a pumping station and collection system., however, to construct and modify a pumping station, a Water Quality Management Part II Permit Sewer Extensions and Pumping Stations permit must be obtained.
- A National Pollutant Discharge Elimination System (NPDES) permit may be required in the future. Only communities with a treatment facility must have a NPDES permit that must be renewed every five years.
- Reporting requirements can be found in the Pennsylvania Code Title 25 Environmental Protection § 94.12. Annual Report.
- There are three main tasks associated with the operation and maintenance of pumping stations including scheduling, record keeping and equipment maintenance.
- Typical routine maintenance items include the following: Lubricate and change oil, inspect for vibration/noises that might indicate loss, failure or other problem, Exercise valves and Inspect the wet well and note the condition.
- More specific maintenance tasks include those associated with electrical systems, pumps and motors.
- Routine annual inspection of electrical equipment should include an examination, replacement of worn and expendable parts and operational checks and tests.
- Routine maintenance of motors includes lubrication and inspections to ensure they are operating well within manufacturing specs.
- Routine maintenance of pumps should include the pump impellers be inspected for wear on a regular basis and adjusted to maintain proper tolerance.as well as the operator should listening to the pump for cavitation noises and any other noises or vibrations that might indicate bearing failure.
- Compressors must be maintained by cleaning and replacing filters every 3 to 6 months, lubricating bearings, cleaning casing fins, draining condensate form the air compressor, and inspecting belt tension.
- A lubrication schedule should be developed to ensure that all equipment that requires lubrication receives the correct lubrication at the time frame required.



Exercise

1. Routine annual inspection of electrical equipment should include:
 - a. an examination
 - b. replacement of worn and expendable parts
 - c. operational checks and tests
 - d. all of the above

2. List 4 items that should be part of the records for a sanitary sewer line.
 - a. _____
 - b. _____
 - c. _____
 - d. _____

3. A permit is required to install and operate a pump station.
 - a. True
 - b. False

4. List 4 important maintenance procedures for compressors and indicate how often they should be done.
 - a. _____
 - b. _____
 - c. _____
 - d. _____

5. Pump bearing failure may be preceded by cavitation sounds, unusual noises or vibration.
 - a. True
 - b. False

Unit 3 – Safety

Learning Objectives

- Explain the safety procedures for traffic control, confined space entry, excavations and electrical systems.
- List and describe the major hazards associated with a collection system.

Traffic Control

Working in a roadway presents a hazard to the collection system operator. When traffic is going to be affected by work in the roadway, the authority with jurisdiction should be notified. Frequently, a permit is required prior to the start of any work. A traffic control zone consists of an advance warning area, a transition area, a buffer space, a work area and a termination area.

Advanced Warning Area

- ✓ The advanced warning area must be long enough to give motorists time to react.
- ✓ Typical lengths are:
 - ½ to 1 mile for freeways or expressways.
 - 1500 feet for most other roadways or highways.
 - 1 block for urban areas.

Transition Area

- ✓ The transition area is required when a lane closure is required.
- ✓ The area contains a taper, which is a series of channelizing devices and/or pavement markings placed on an angle to move traffic out of the normal traffic lane. The length of the taper is determined based on the speed of traffic, with typical length varying from 150 feet for 25 MPH traffic to 1,000 feet for 55 MPH traffic.

Buffer Space

- ✓ This is the open space between the transition and work areas.

Work Area

- ✓ The work area is the area of roadway that is closed for work activity.
- ✓ Work areas should include a safe entrance and exit for work vehicles, adequate warning devices on the work and/or shadow vehicles, and flashing lights or flags on work vehicles exposed to traffic.

Termination Area

- ✓ The termination area is a short distance to clear the work zone and return to normal traffic lanes.



Confined Space Entry – Manholes

Manholes are confined spaces and are regulated under the Occupation Safety and Health Administration (OSHA).



A **confined space** is a space that is large enough and so configured that a person can bodily enter, has limited or restricted means for entry or exit, and is not designed for continuous occupancy.

- ✓ Confined Space Entry may require the use of a respirator. Self-Contained Breathing Apparatus (SCBA), Supplied Air Respirators (SAR) are air supplying respirators and supply air to the wearer from an independent source.
- ✓ Prior to an operator entering a manhole, a ventilation blower with the hose outlet positioned at the bottom of the manhole must be operated for 10 to 15 minutes. Be careful that truck or blower engine exhaust gases do not get drawn into the blower intake.
- ✓ **An initial test of the atmosphere from the manhole must be performed for the presence of explosive or flammable gases, toxic gases and percentage of oxygen. Oxygen content should be the first test performed because most combustible gas meters are oxygen dependent and will not provide reliable readings in oxygen-deficient atmosphere.**
- ✓ All valves and applicable power sources must be locked out and properly tagged.
- ✓ Whenever an operator is entering a manhole, a safety harness, either chest or full-body, with a lifeline and a hard hat must be worn. In addition, the operator must carry a 5-minute air escape capsule. A confined space entry form must be completed and at the site.
- ✓ A lifeline must be attached at the center of the operator's back near shoulder level or above the entrant's head. Two additional people must be aboveground. One person must remain observing the operator in the manhole and the second person must remain within calling distance because it would take two people to pull the operator out of the manhole if something happened.
- ✓ No smoking is permitted inside or within 10 feet of the confined space.

- ✓ When the operator is in the manhole, an atmospheric alarm unit should continuously monitor the atmosphere from the manhole for the presence of explosive or flammable gases, toxic gases and percentage of oxygen. If any warning alarms sound, all persons in the confined space area vacate immediately.

- ✓ A winch is typically used to raise or lower the operator wearing the safety harness. A bucket is used to lower tools to the operator in the confined space.

Confined Space Pre-Entry Checklist/Confined Space Entry Permit

Date and Time Issued: _____ Date and Time Expires: _____ Job Site/Space I.D.: _____

Job Supervisor: _____ Equipment to be worked on: _____ Work to be performed: _____

Standby personnel: _____

1. Atmospheric Checks: Time _____ Oxygen _____ % Toxic _____ ppm
 Explosive _____ % LEL Carbon Monoxide _____ ppm

2. Tester's signature: _____

3. Source isolation: (No Entry) N/A Yes No
 Pumps or lines blinded disconnected, or blocked () () ()

4. Ventilation Modification: N/A Yes No
 Mechanical () () ()
 Natural ventilation only () () ()

5. Atmospheric check after isolation and ventilation: Time _____
 Oxygen _____ % > 19.5% < 23.5% Toxic _____ ppm < 10 ppm H₂S
 Explosive _____ % LFL < 10% Carbon Monoxide _____ ppm < 35 ppm CO

Tester's signature: _____

6. Communication procedures: _____

7. Rescue procedures: _____

8. Entry, standby, and backup persons Yes No
 Successfully completed required training? () ()
 Is training current? () ()

9. Equipment: N/A Yes No
 Direct reading gas monitor tested () () ()
 Safety harnesses and lifelines for entry and standby persons () () ()
 Hoisting equipment () () ()
 Powered communications () () ()
 SCBAs for entry and standby persons () () ()
 Protective clothing () () ()
 All electric equipment listed for Class I, Division I, Groups A, B, C, and D and nonsparking tools () () ()

10. Periodic atmospheric tests:
 Oxygen: _____% Time _____; _____% Time _____; _____% Time _____; _____% Time _____;
 Explosive: _____% Time _____; _____% Time _____; _____% Time _____; _____% Time _____;
 Toxic: _____ppm Time _____; _____ppm Time _____; _____ppm Time _____; _____ppm Time _____;
 Carbon Monoxide: _____ppm Time _____; _____ppm Time _____; _____ppm Time _____; _____ppm Time _____;

We have reviewed the work authorized by this permit and the information contained herein. Written instructions and safety procedures have been received and are understood. Entry cannot be approved if any brackets () are marked in the "No" column. This permit is not valid unless all appropriate items are completed.

Permit Prepared By: (Supervisor) _____ Approved By: (Unit Supervisor) _____

Reviewed By: (CS Operations Personnel) _____
 (Entrant) (Attendant) (Entry Supervisor)

This permit to be kept at job site. Return job site copy to Safety Office following job completion.

Figure 3.1 Confined Space Pre-entry Checklist/Permit ¹

Excavations

Excavations present a combination of hazards.

- ✓ Prior to beginning any excavation work, underground utilities need to be contacted and their respective lines located.
- ✓ OSHA requires that a protective system is used in trenches 5 feet or deeper. A proper protective system is required to ensure that the walls of the excavation do not cave in.
 - Shoring is a complete framework designed to support the trench walls.
 - Shielding is the placement of a 2-sided, braced steel box in the trench. Operators using a shielding must always work within the walls of the shield.
 - Sloping/benching is the practice of removing the trench wall at a designated slope.
 - Soil removed from a trench should be placed a minimum of 2 feet from the trench and should only be placed on one side of the trench.
- ✓ A means of egress, such as a ramp or ladder, must be placed so that no more than 25 feet of travel is required in trenches that are more than 4 feet deep.
- ✓ Walkways must be provided where operators cross the trench and if the trench is greater than 6 feet deep, guide rails must be provided on the walkways.
- ✓ Excavations and adjacent areas must be inspected daily by a competent person.
- ✓ Atmospheric monitoring is required prior to entering an excavation greater than 4 feet deep if a hazardous atmosphere can be reasonably expected.

Electrical

If you are not qualified to work on electrical equipment, you should not under any circumstance attempt to work on electrical equipment. If you are qualified, the following rules should be observed:

- ✓ Disconnect and lockout all equipment prior to working on it.
- ✓ Use rubber mats, rubber boots, leather gloves or some other form of isolation between you and the ground.
- ✓ Avoid wearing anything with metal, such as eyeglasses, jewelry and belt buckles, because metal increases the possibility of severe burns or electrocution if an item with metal comes into contact with electrical circuits.
- ✓ Maintain adequate clearance of body parts with live circuits.
- ✓ Work with only one hand around energized circuits. This will minimize the possibility of completing a circuit.
- ✓ Have an observer certified in cardiopulmonary resuscitation (CPR) present when you work on energized circuits at or above a certain voltage level.
- ✓ Wear safety glasses when working on live equipment.
- ✓ Prior to resetting tripped circuit breakers, investigate the cause of the tripping.

Accidents and Injuries

There are six major categories of hazards that are associated with entering a manhole.

Atmospheric Hazards

Consist of three main types:

- ✓ Explosive and flammable atmospheres in the collection system may be the result of the formation of methane gas, which is colorless and odorless, or flammable liquids from illegal discharges or underground tank leakage. If flammable liquids have been detected, the operator should immediately notify the police, fire and emergency agencies.
- ✓ Toxic atmospheres (poisonous air) in the collection system from the formation of hydrogen sulfide (H₂S).
- ✓ Depletion or enrichment of breathable oxygen in the manhole: Oxygen may be depleted when replaced by another gas or can be enriched when pure oxygen (O₂) is added to the collection system.

Physical Injuries

Physical injuries may occur when entering a manhole. Typical injuries include:

- ✓ Falling from manhole rungs that have deteriorated.
- ✓ Having tools dropped from above.
- ✓ Dust and debris from the manhole ring falling into the eyes.
- ✓ Being cut by sharp objects such as needles, broken glass or metal, that may be in the collection system.

Infection and Disease

- ✓ Infections are always potentially present in a collection system because almost every disease and infection from the community ends up in the collection system.
- ✓ In addition, operators can contract Leptospirosis by contact with rat urine and feces.

Insects and Biting Animals

- ✓ Manholes may house insects, bugs or rodents that may sting or bite the operator.
- ✓ Mosquito bites could transmit malaria or West Nile Virus and rat bites could transmit rabies.

Toxic Exposure

Exposure to toxic substances is a potential health hazard.

- ✓ Toxic substances that may be in a collection system include acids, bases or other hazardous liquids that enter the system from a regulated industry, by an accident or by illegal discharge.

Drowning

- ✓ Large diameter sewers may have high flow rates which may lead to an operator falling and drowning in the flowing wastewater.



Unit 3 – Safety

Key Points

- Collection system personnel must be familiar with the safety procedures for traffic control, confined space entry, excavations and electrical systems.
- A traffic control zone consists of an advance warning area, a transition area, a buffer space, a work area and a termination area.
- One of the biggest dangers for collection system personnel is confined space entry.
- OSHA requires that a protective system is used in trenches 5 feet or deeper.
- If you are not qualified to work on electrical equipment, you should not under any circumstance attempt to work on electrical equipment.
- Accidents associated with working in or on a collection system include atmospheric hazards, physical injuries, infectious diseases, insects and biting animals, toxic exposure and finally drowning.
- When working in a manhole the area in and around should be continuously monitored for dangerous gaseous such as methane and hydrogen sulfide.

**Exercise**

1. Which of the following is not part of a traffic control zone?
 - a. A termination area.
 - b. An advance warning area.
 - c. An emergency pull-off.
 - d. A transition area.

2. Which of the following does not define a confined space?
 - a. It is large enough and so configured that a person can bodily enter it.
 - b. It is not designed for continuous occupancy.
 - c. It does not provide sufficient natural light.
 - d. It has limited or restricted means for entry.

3. Which of the following is a major hazard of entering a manhole?
 - a. Toxic exposure.
 - b. Physical injuries.
 - c. Psychological trauma.
 - d. Infection and disease.
 - e. All of the above.

4. No smoking is permitted inside or within 10 feet of a confined space.
 - a. True
 - b. False

5. Prior to beginning any excavation work, underground _____ need to be contacted and their respective lines located.

6. Work on electrical equipment should only be done by qualified and trained workers.
 - a. True
 - b. False

7. OSHA requires that a protective system be used in trenches _____ feet or deeper.

¹ George Freeland, "Safe Procedures", in *Operation and Maintenance of Wastewater Collection Systems: A Field Study Training Program*, Vol I, (Sacramento California: California State University, Sacramento Foundation, 1999), p. 184.