Ethiopian TVET-System

Irrigation and Drainage Design and Construction

Level-III

Based on Feb, 2017G.C. Occupational Standard

Module Title: Monitoring Operation and Maintenance of Pump Stations

TTLM Code: EIS IDD3 TTLM 0920v2

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This module includes the following Learning Guides

LG 51: Plan and prepare work

LG Code: EIS IDD3 M14 LO1-LG-51

LG 52: Operate pump stations

LG Code: EIS IDD3 M14 LO2-LG-52

LG 53: Maintain pump stations

LG Code: EIS IDD3 M14 LO3-LG-53

LG 54: Monitor and adjust pump station performance

LG Code: EIS IDD3 M14 LO4-LG-54

LG 55: Finalise work

LG Code: EIS IDD3 M14 LO5-LG-55

Instruction Sheet	Learning Guide 51: Plan and prepare work

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Determining pump station work requirements from standard operating and maintenance procedures.
- Accessing and interpreting pump operation and maintenance procedures
- Performing site check to prevent damage to other utilities and the environment, according to legislative and organisational requirements.
- Selecting and checking equipment to meet safety requirements of task and selecting, fitting and using site and personal protective equipment
- Handling, using and storing chemicals according to organisational requirements.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Determine pump station work requirements from standard operating and maintenance procedures.
- Access and interpret pump operation and maintenance procedures
- Perform site check to prevent damage to other utilities and the environment, according to legislative and organisational requirements.
- Select and check equipment to meet safety requirements of task and select, fit and use site and personal protective equipment
- Handle, use and store chemicals according to organisational requirements.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 5”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3,4 and 5 ” in each information sheets on pages 28, 29,33,39, 50,51,52 and 61.

5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1 on pages 63 and do the LAP Test on page 64”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Determining pump station work requirements

1.1 Introduction to irrigation pumps

Liquid can only move on its own power, and then only from top to bottom or from a high pressure to a lower pressure system. This means that energy to the liquid must be added, to move the liquid from a low to a higher level. To add the required energy to liquids, pumps are used.

A pump is a machine used for the purpose of transferring quantities of liquids, gases and even solids from one location to another.

Almost all irrigation systems, except gravity feed systems, rely on pumps to pump water to the field blocks or orchards and supply the desired pressure to the system to work properly. The pump moves, or displaces, water by sucking water from the source, such as a river, dam, reservoir, etc., and propelling in through the irrigation system.

Efficient irrigation begins with properly installed, operated and maintained pumps, motors, and engines. Equipment problems and management problems tend to go hand in hand. Equipment that is badly designed, operated or poorly maintained reduces the irrigator's degree of control over the way water is applied. Problems like patchy water distribution and inadequate pressure make it impossible to maintain correct soil moisture levels, leading to crop stress, reduced yields, wasted water, runoff, soil erosion, and many other problems.

1.2 Types of pumps

Pump types generally fall into two main categories – **Roto-dynamic** and **Positive displacement**, of which there are many forms. The roto-dynamic pump transfers rotating mechanical energy into kinetic energy in the form of fluid velocity and pressure. The Centrifugal and special effect pumps are types of roto-dynamic pump, which utilize centrifugal force to transfer the fluid being pumped. The positive displacement pump directly displaces the pumped fluid from pump inlet to outlet in discrete volumes. Example of roto-dynamic pump includes Centrifugal Pump, Turbine Pump(Deep well turbine and Submersible pump), Propeller Pump, Jet Pump, Air Lift Pump.

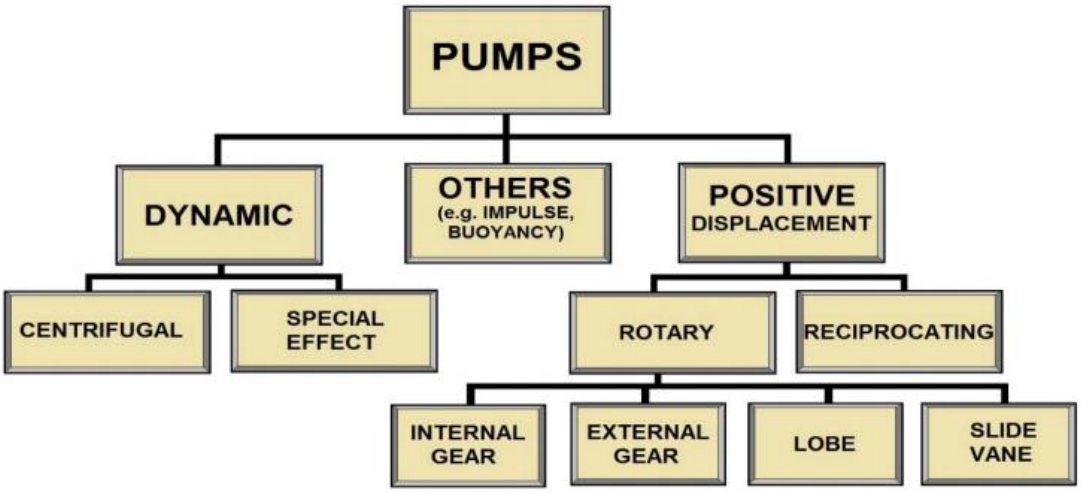


Figure 1. Types of pump

1.2.1 Roto-dynamic

A centrifugal pump is the most common type of roto-dynamic pump. Its purpose is to convert energy of a prime mover (a electric motor or turbine) first into velocity or kinetic energy and then into pressure energy of a fluid that is being pumped. The energy changes occur by virtue of two main parts of the pump, the **impeller** and the **volute** or **diffuser.**

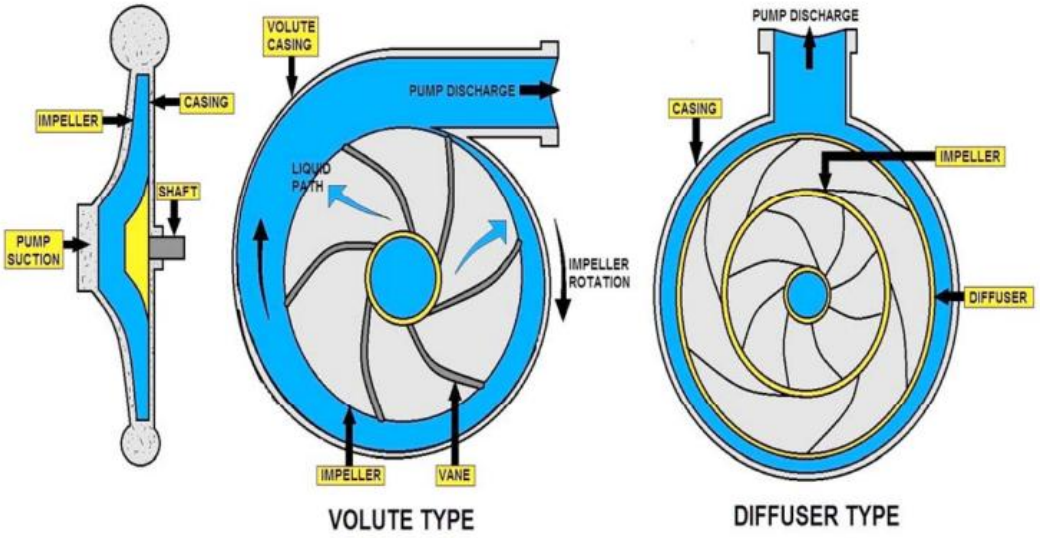


Figure 2. Centrifugal pump volute and diffuser

The impeller is the rotating part that converts driver energy into the kinetic energy. The volute or diffuser is the stationary part that converts the kinetic energy into pressure energy.

The process liquid enters the suction nozzle and then into eye (center) of a revolving device known as an impeller. When the impeller rotates, it spins the liquid sitting in the

cavities between the vanes outward and provides centrifugal acceleration. As liquid leaves the eye of the impeller a low-pressure area is created causing more liquid to flow toward the inlet. Because the impeller blades are curved, the fluid is pushed in a tangential and radial direction by the centrifugal force.

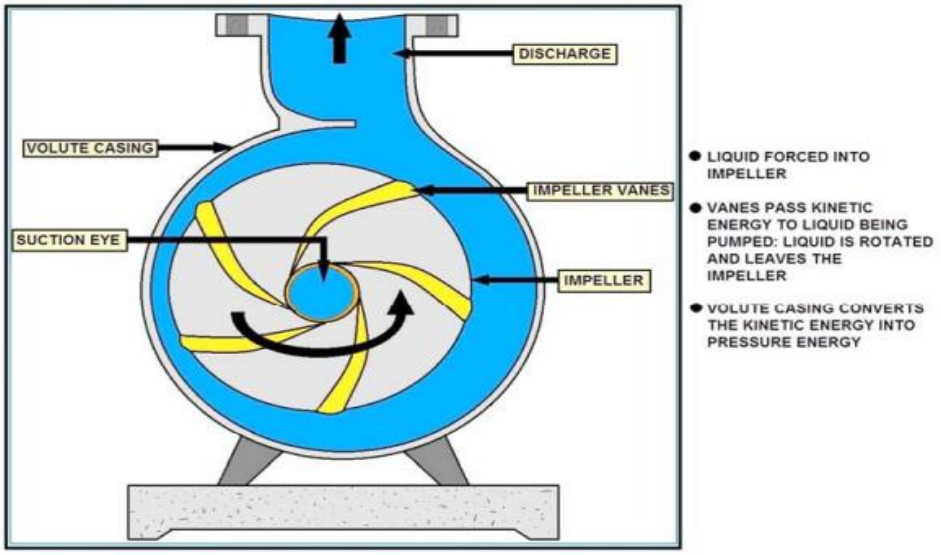


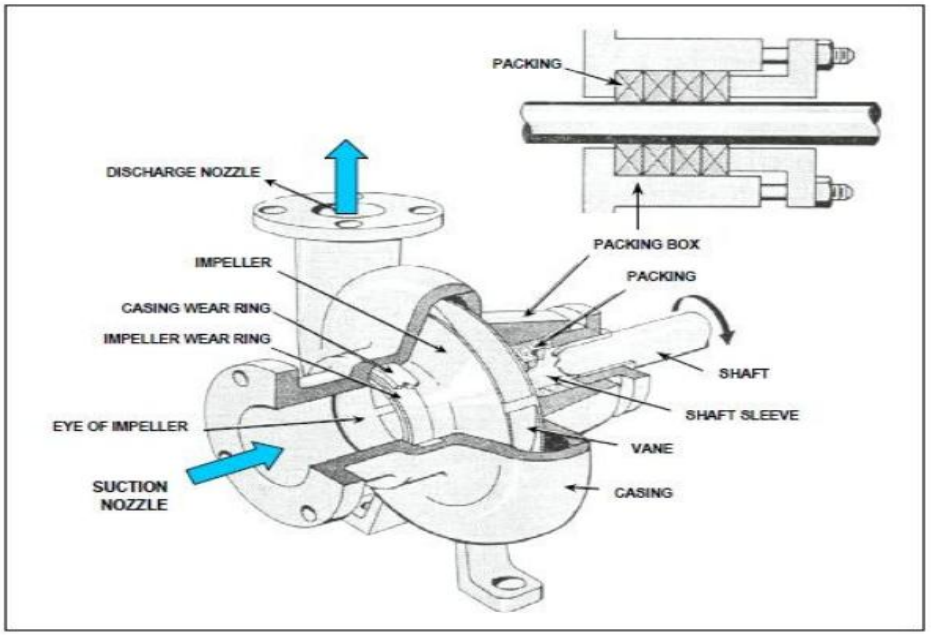
Figure 3. Working principle of a centrifugal pump

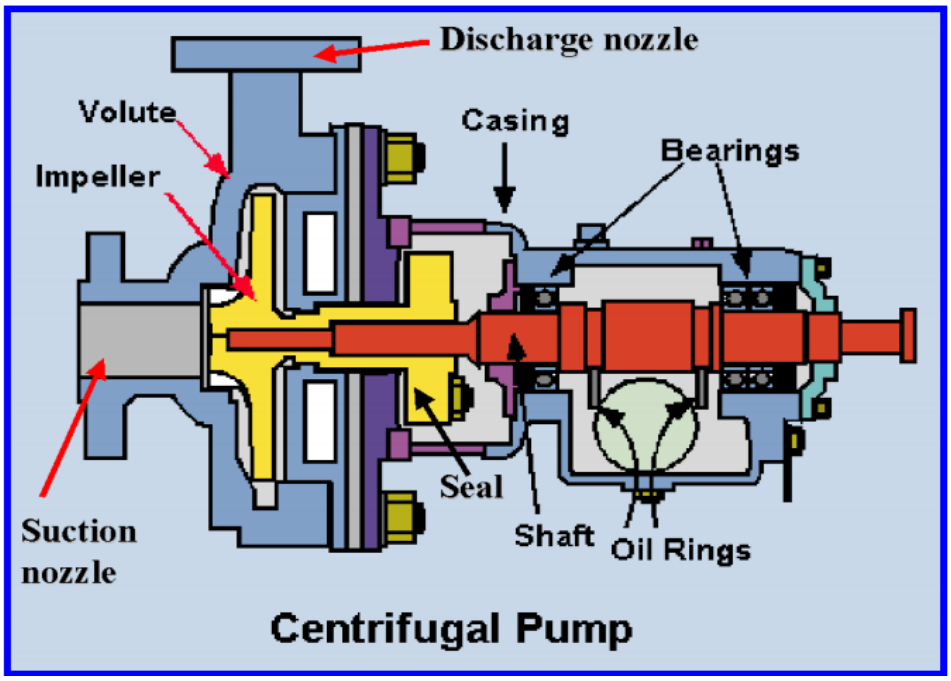
1.2.1.1 General Components of Centrifugal Pumps

A centrifugal pump has two main components:

I. A rotating component comprised of an impeller and a shaft

II. A stationary component comprised of a casing, casing cover, and bearings





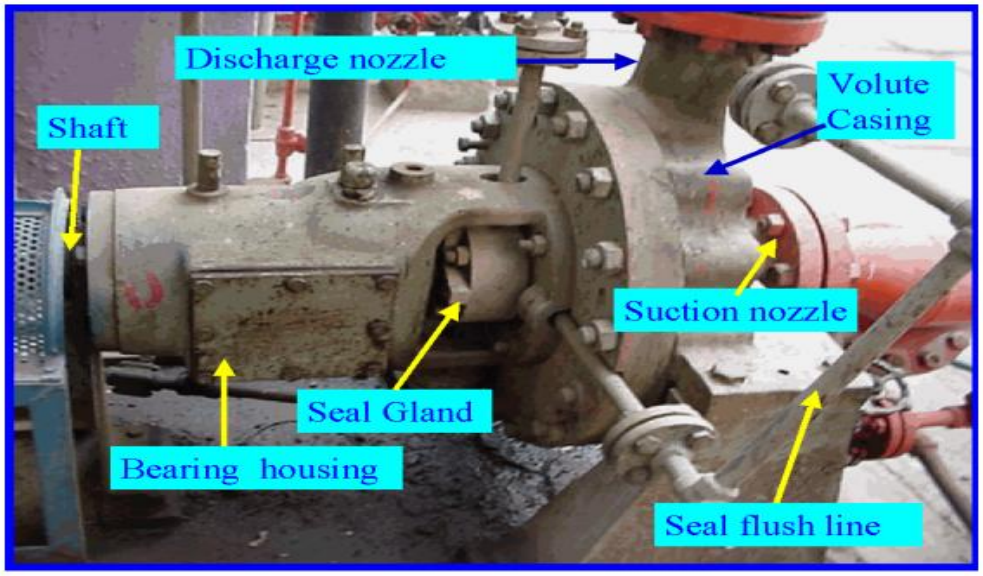


Figure 4. Component part of centrifugal pump

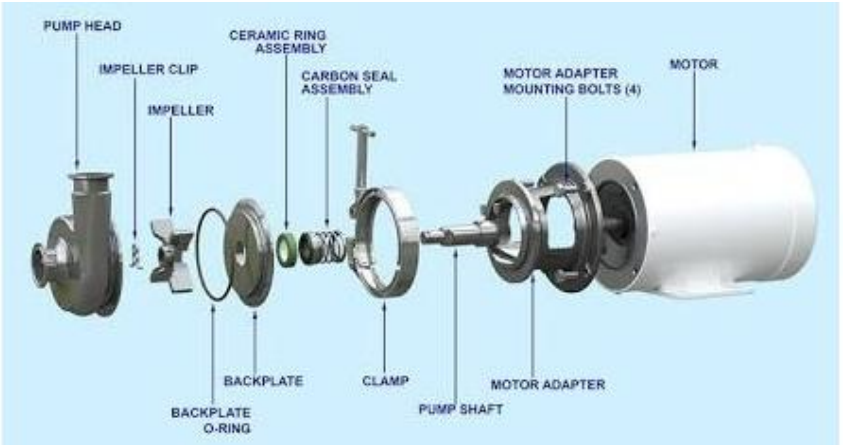


Figure 5. Detail component of centrifugal pump

A. Stationary Components

1. Casing

Casings are generally of two types: **volute and circular**. The impellers are fitted inside the casings.

Volute casings build a higher head; circular casings are used for low head and high capacity.

- A volute is a curved funnel increasing in area to the discharge port. As the area of the cross- section increases, the volute reduces the speed of the liquid and increases the pressure of the liquid.

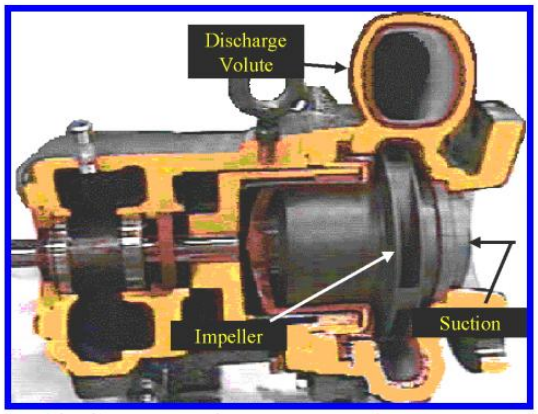


Figure 6. Cut-away of pump showing volute casing

Circular casing have stationary diffusion vanes surrounding the impeller periphery that convert velocity energy to pressure energy. Conventionally, the diffusers are applied to multi - stage pumps

- The casings can be designed either as solid casings or split casings. Solid casing implies a design in which the entire casing including the discharge nozzle is all contained in one casting or fabricated piece. A split casing implies two or more parts are fastened together.

Figure 7. Solid casing

2. Suction and Discharge Nozzle

The suction and discharge nozzles are part of the casings itself. They commonly have the following configurations.

i. **End suction/Top discharge** - The suction nozzle is located at the end of, and concentric to, the shaft while the discharge nozzle is located at the top of the case perpendicular to the shaft.

ii. **Top suction Top discharge nozzle**- The suction and discharge nozzles are located at the top of the case perpendicular to the shaft.

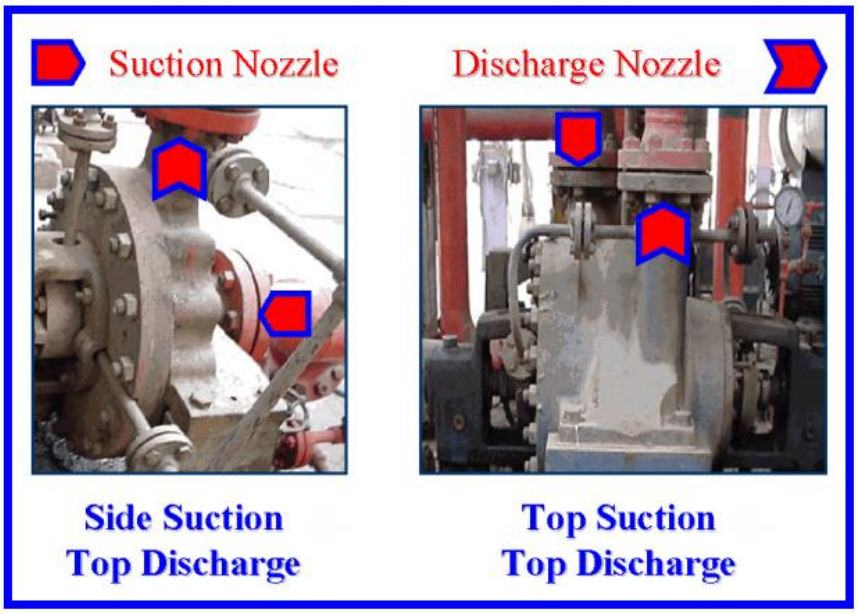


Figure 8. Suction and discharge nozzle locations

iii. **Side suction / Side discharge nozzles** - The suction and discharge nozzles are located at the sides of the case perpendicular to the shaft.

3. Seal Chamber and Stuffing Box

Seal chamber and Stuffing box both refer to a chamber, either integral with or separate from the pump case housing that forms the region between the shaft and casing where sealing media are installed. When the sealing is achieved by means of a mechanical seal, the chamber is commonly referred to as **a Seal Chamber**. When the sealing is achieved by means of packing, the chamber is referred to as a **Stuffing Box**. Both the seal chamber and the stuffing box have the primary function of protecting the pump against leakage at the point where the shaft passes out through the pump pressure casing.

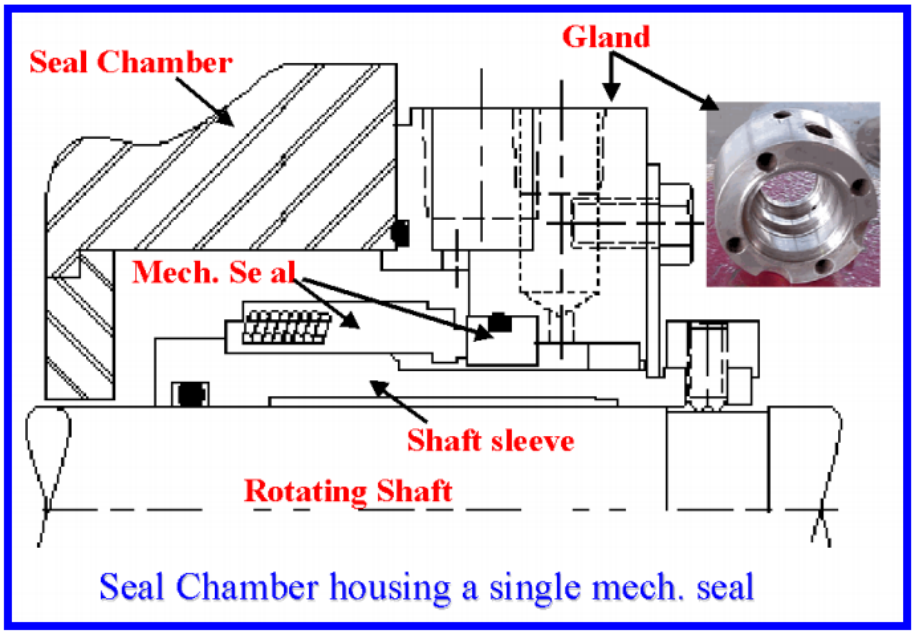


Figure 9. Parts of a simple seal chamber

Gland: gives the pickings or the mechanical seal the desired fit on the shaft sleeve. It can be easily adjusted in axial direction. The gland comprises of the seal flush, quench, cooling, drain, and vent connection ports.

Throat Bushing: The bottom or inside end of the chamber is provided with a stationary device called throat bushing that forms a restrictive close clearance around the sleeve (or shaft) between the seal and the impeller.

Throttle bushing refers to a device that forms a restrictive close clearance around the sleeve (or shaft) at the outboard end of a mechanical seal gland.

Internal circulating device refers to device located in the seal chamber to circulate seal chamber fluid through a cooler or barrier/buffer fluid reservoir. Usually it is referred to as a pumping ring.

Mechanical Seal

In some situations, packing material is not adequate for sealing the shaft. One common alternative method for sealing the shaft is with mechanical seals. Mechanical seals consist of two basic parts, a rotating element attached to the pump shaft and a stationary element attached to the pump casing.

Figure 10. Mechanical seal

4. Bearing housing

The bearing housing encloses the bearings mounted on the shaft. The bearings keep the shaft or rotor in correct alignment with the stationary parts under the action of radial and transverse loads. The bearing house also includes an oil reservoir for lubrication, constant level oiler, jacket for cooling by circulating cooling water

B. Rotating Components

1. Impeller

The impeller is the main rotating part that provides the centrifugal acceleration to the fluid. A centrifugal pump may have only one impeller which is called **Single Stage or Multi-Stage** having two or more impellers housed together in one casing

Impellers are often classified in many ways as follows.

Based on major direction of flow in reference to the axis of rotation

- **Radial flow:** the pressure is developed wholly by centrifugal force.

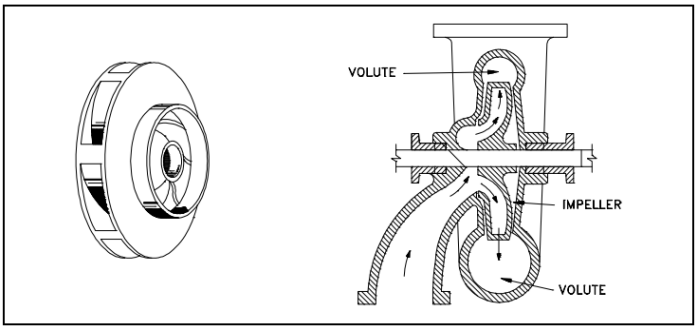


Figure 11. Radial flow centrifugal pump

- **Mixed flow:** the pressure is developed partly by centrifugal force and partly by the lift of the vanes of the impeller on the liquid.

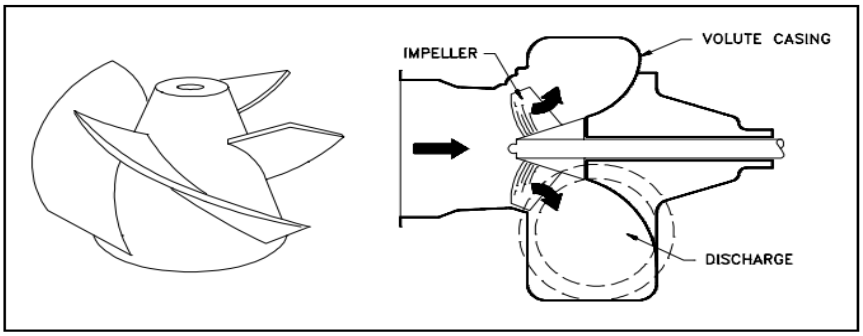


Figure 12. Mixed flow centrifugal pump

- **Axial flow:** the pressure is developed by the propelling or lifting action of the vanes of the impeller on the liquid.

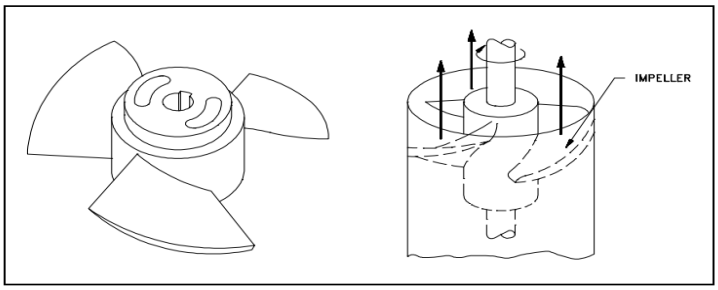


Figure 13. Axial flow centrifugal pump

Based on suction type

- **Single- suction:** Liquid inlet on one side.
- **Double- suction:** Liquid inlet to the impeller symmetrically from both sides.

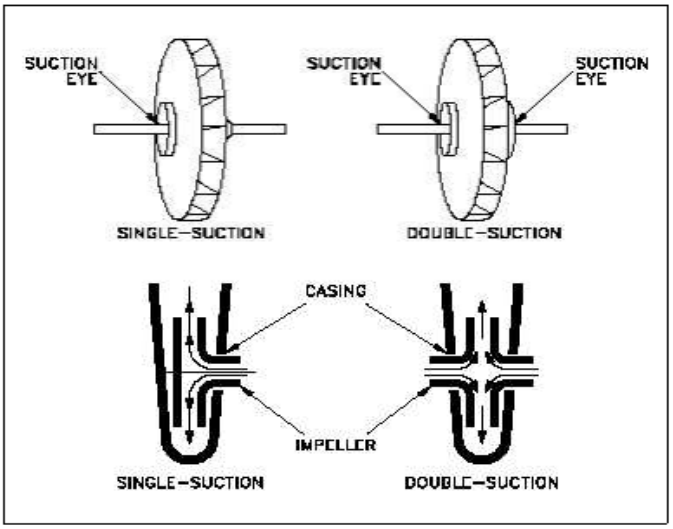


Figure 14. Single and double suction impellor

Based on mechanical construction

- **Closed**: Shrouds or sidewall enclosing the vanes.
- **Open**: No shrouds or wall to enclose the vanes.
- **Semi - open** or vortex type.

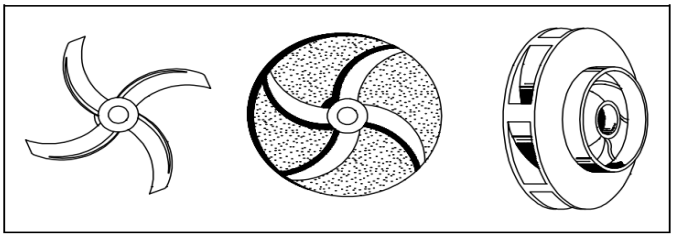


Figure 15. Open, semi open and closed impellor

Closed impellers require wear rings and these wear rings present another maintenance problem. Open and semi - open impellers are less likely to clog, but need manual adjustment to the volute or back- plate to get the proper impeller setting and prevent internal re- circulation.

Wear rings: Wear ring provides an easily and economically renewable leakage joint between the impeller and the casing. Clearance becomes too large the pump efficiency will be lowered causing heat and vibration problems.

2. Shaft

The basic purpose of a centrifugal pump shaft is to transmit the torques encountered when starting and during operation while supporting the impeller and other rotating parts.

Figure 16. Shaft

Shaft Sleeve: Pump shafts are usually protected from erosion, corrosion, and wear at the seal chambers, leakage joints, internal bearings, and in the waterways by renewable sleeves. Leakage between the shaft and the sleeve should not be confused with leakage through the mechanical seal

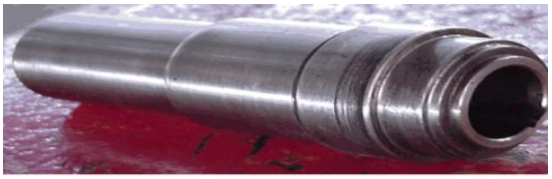


Figure 17. Shaft sleeve

Coupling: Couplings can compensate for axial growth of the shaft and transmit torque to the impeller. Shaft couplings can be broadly classified into two groups: rigid and flexible. Rigid couplings are used in applications where there is absolutely no possibility or room for any misalignment. Flexible shaft couplings are more prone to selection, installation and maintenance errors.

Refer the following you tube video links for centrifugal pump

1. https://www.youtube.com/watch?v=XpcCUtYzwy0
2. https://www.youtube.com/watch?v=BaEHVpKc-1Q
3. https://www.youtube.com/watch?v=TxqPAPg4nb4
4. https://www.youtube.com/watch?v=oLUjy8Iyfbk

Vertical turbine pumps

Vertical turbine pumps are available in deep well, shallow well, or canned configurations. These pumps are also suitable industrial, municipal, commercial and agricultural applications. Deep well turbine pumps are adapted for use in cased wells or where the water surface is below the practical limits of a centrifugal pump.

Turbine pumps are also used with surface water systems. Since the intake for the turbine pump is continuously under water, priming is not a concern. Turbine pump efficiencies are comparable to or greater than most centrifugal pumps. They are usually more expensive than centrifugal pumps and more difficult to inspect and repair.

The turbine pump has three main parts:

1. **The head assembly**
2. **The shaft and column assembly**
3. **The pump bowl assembly**

The head is normally cast iron and designed to be installed on a foundation. It supports the column, shaft, and bowl assemblies, and provides a discharge for the water. It also will support an electric motor, a right angle gear drive or a belt drive.

Bowl Assembly

The bowl assembly is the heart of the vertical turbine pump. The impeller and diffuser type casing is designed to deliver the head and capacity that the system requires in the most efficient way. The submerged impellers allow the pump to be started without priming. The discharge head changes the direction of flow from vertical to horizontal, and couples the pump to the system piping, in addition to supporting and aligning the driver. A variety of drivers may be used; however, electric motors are most common.

Column Assembly

The shaft and column assembly provides a connection between the head and pump bowls. The line shaft transfers the power from the motor to the impellers and the column

carries the water to the surface. The line shaft on a turbine pump may be either water lubricated or oil lubricated. The oil-lubricated pump has an enclosed shaft into which oil drips, lubricating the bearings.

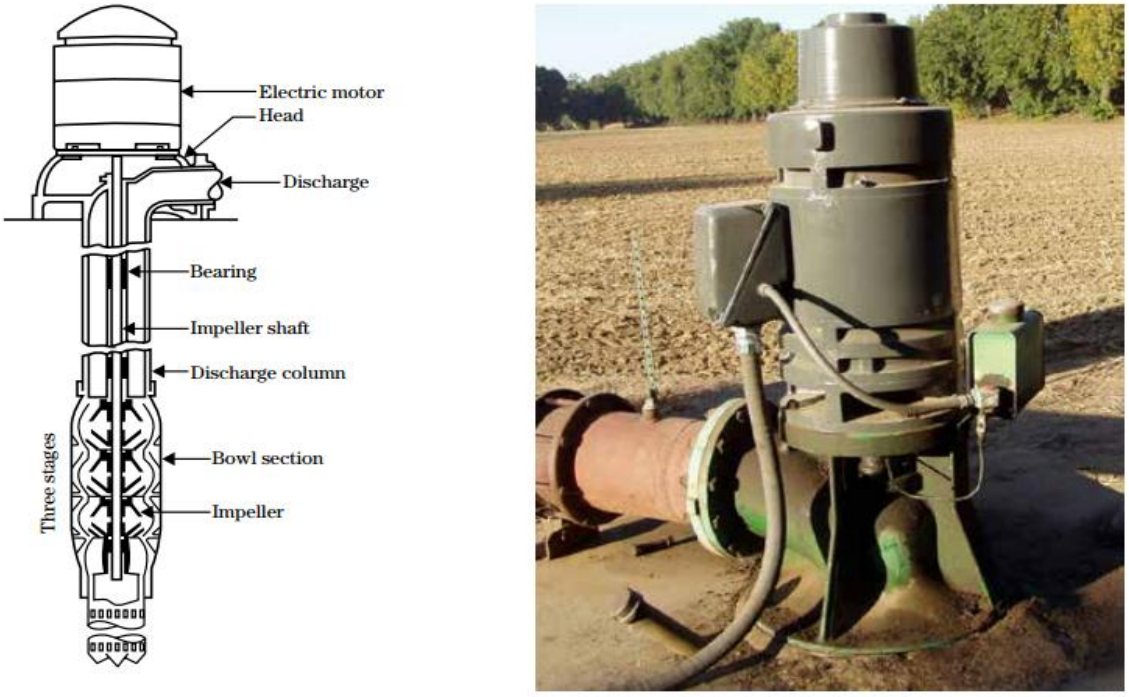


Figure 18. Vertical turbine pump

Refer the following video link for turbine pump

1. https://www.youtube.com/watch?v=IYbyXlXxTig

Submersible Pump fundamentals

The submersible pump is simply a turbine pump close coupled to a submersible electric motor attached to the lower side of the turbine. Both pump and motor are suspended in the water, thereby eliminating the long-line shaft and bearing retainers that are normally required for a conventional deep-well turbine pump. Operating characteristics are the same as described for deep-well turbine pumps.

Submersible pumps are adapted to cased wells of 4 inches in diameter or larger and settings generally in excess of 50 feet deep. The short line shaft makes it particularly suited to deep settings and crooked wells. As the submersible pump has no above-ground working parts, it can be used where flooding may be a hazard by sealing the well and placing the starting box, meter, and transformer on a pole above high water. It is also

adaptable to locations where aboveground pump facilities would be unsightly or hazardous.

The submersible pump consists of a pump and motor assembly, a head assembly, discharge column, and a submarine cable to furnish power to the motor, The pump, being a centrifugal-type turbine, is equipped with either closed impellers or open impellers or some modification of these two types arranged in series. The closed-impeller type is generally used where it is necessary for the pump to develop high pressures. Water enters the pump through a screen located between the motor and pump

Refer the following you tube video link for submersible pump

1. https://www.youtube.com/watch?v=L0Q6cboXyLY

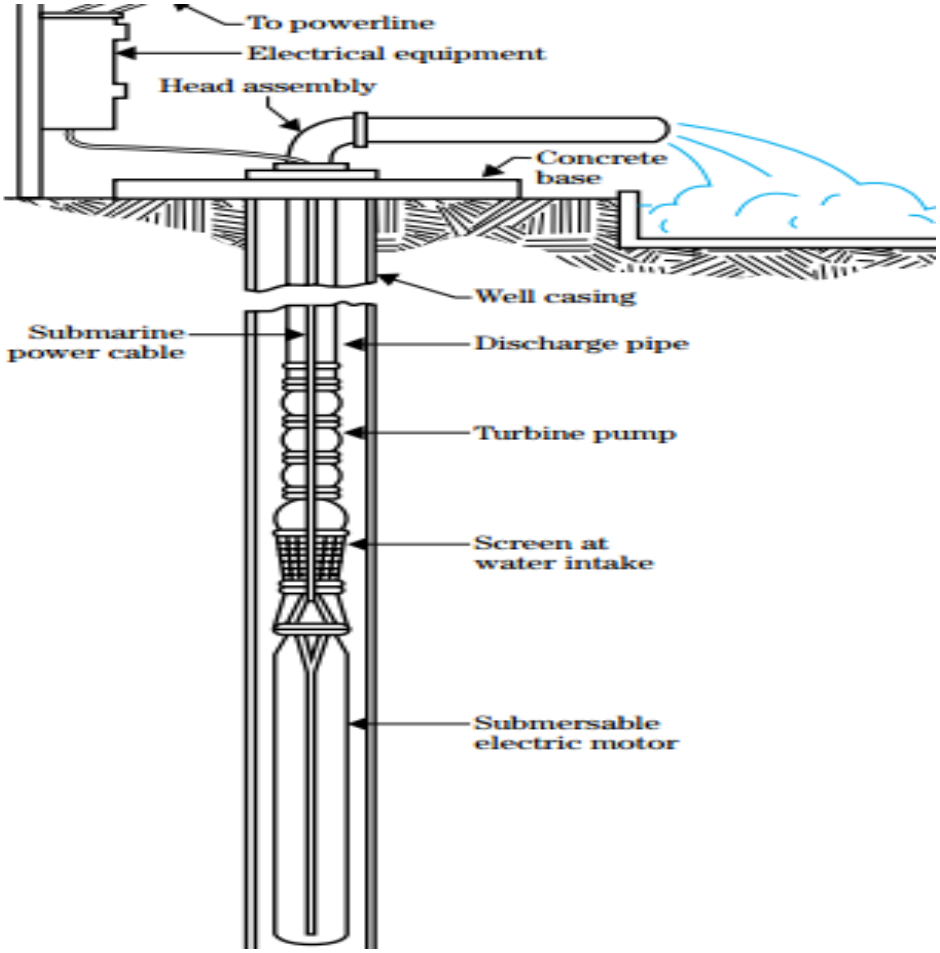


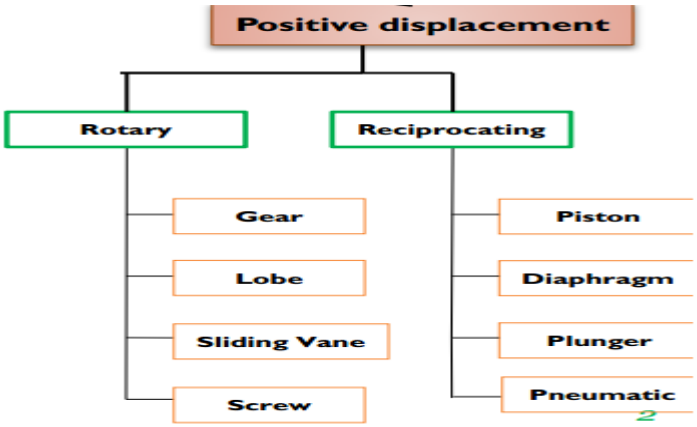
Figure 19. Submersible pump

1.2.2 Positive Displacement Pumps

A pump in which measured quantity of fluid is physically entrapped in a space, its pressure is raised and then it is delivered through the delivery pipe, is called as positive displacement pump. Hand pump is a good example of positive displacement

pump. These pumps may be categorized as **Reciprocating pumps** and **Rotary Pumps**. Under reciprocating type, the displacement of water takes place by reciprocation of piston plunger. If the displacement of water is by rotary action of gears or lobs, it is called a rotary pump.

Types of Displacement Pumps



1. Rotary:- Rotating action occurs periodically.

- **Gear** – comprises two gears in a housing with small radial end clearances.

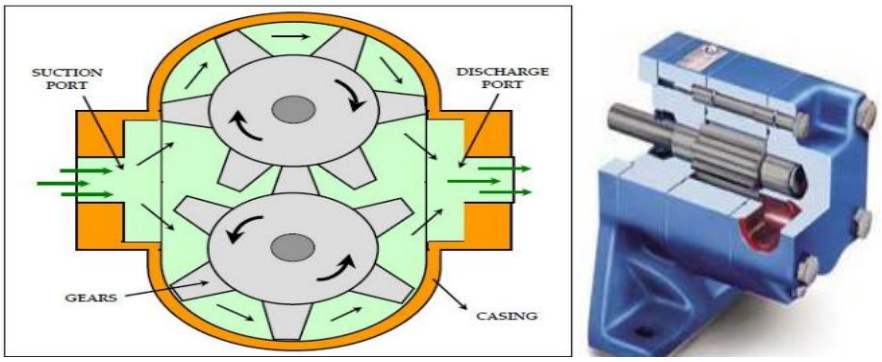


Figure 20. Gear pump

- **Lobe-** Handles solids also.

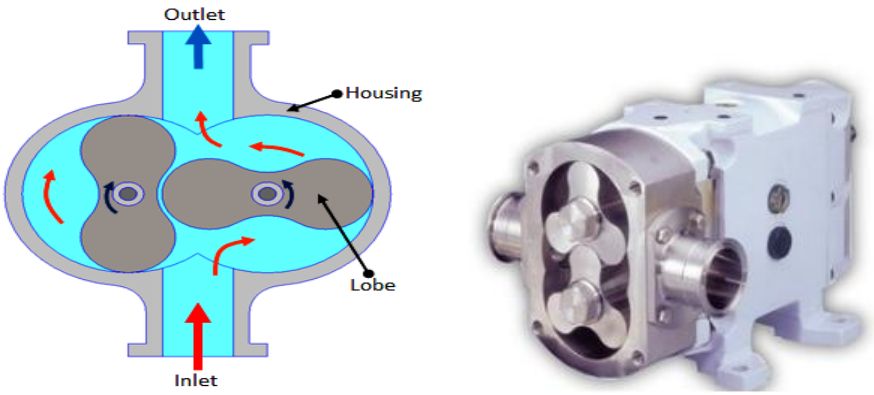


Figure 21. Lobe pump

- **Sliding Vane** – comprises number of vanes.

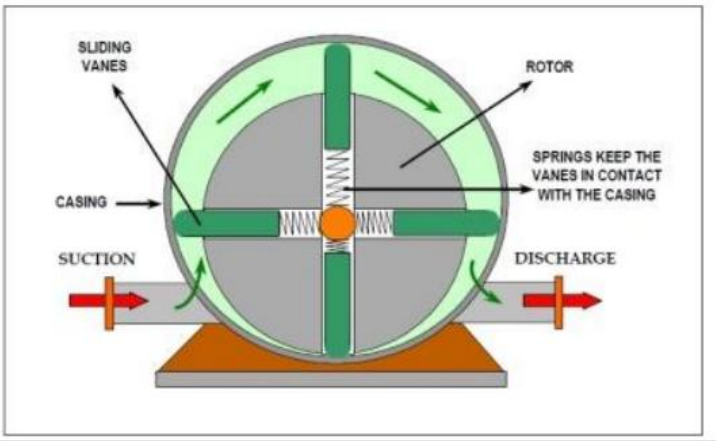


Figure 22. Vane pump

- **Screw-** three screw with housing is used with housing.

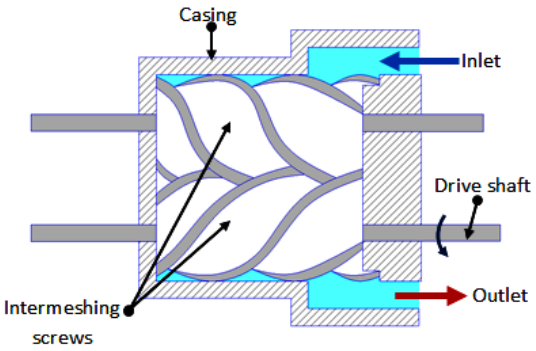


Figure 23. Screw pump

2. Reciprocating:- Reciprocating action occurs periodically.

The main components of a reciprocating positive displacement pump kit, include the following:

- Drive……electric motor
- Drive unit…….gear for increasing torque and housing a crank drive
- Diaphragm pump head…….with plunger and hydraulic part for driving the diaphragm
- Fluid valves for controlling the flow
- Valve body for adaptation to the specific customer piping

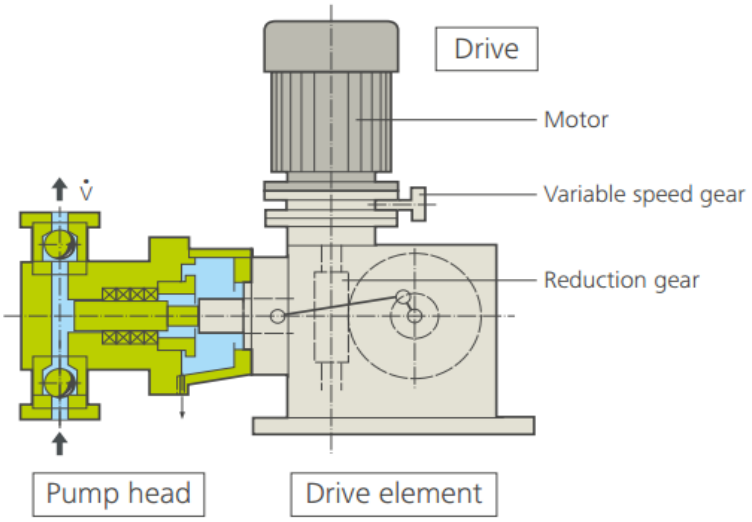


Figure 24. Component parts of reciprocating positive displacement

Types of reciprocating pump

- **Piston** – comprises a cylinder and piston,

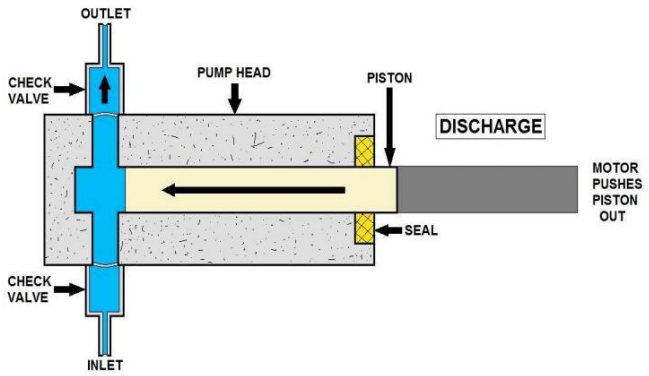


Figure 25. Piston pump

- **Diaphram –** comprises flexible diaphram made from rubber or rubberised febric

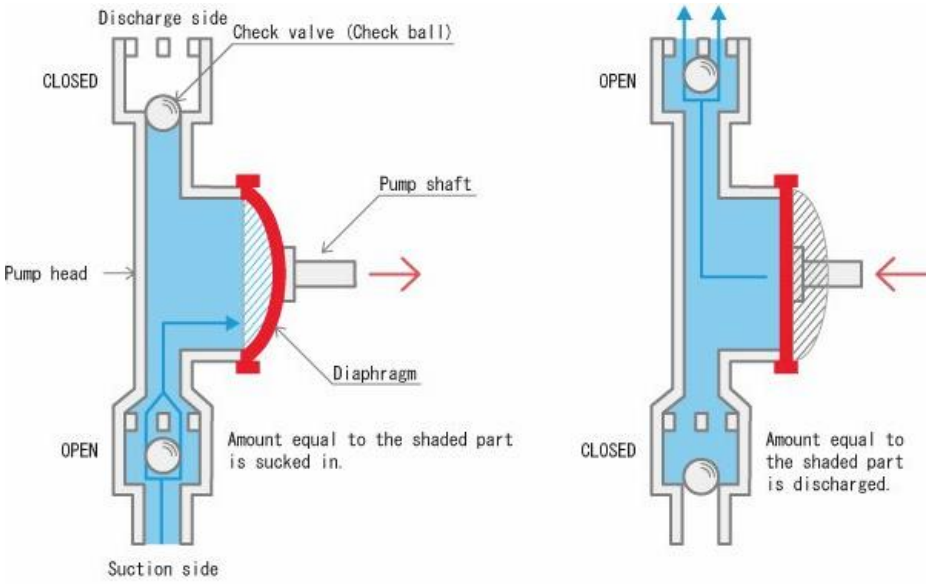


Figure 26. Diaphram pump

- **Plunger** – comprises plunger, uses crank mechanism
- **Pneumatic –** Handles compressed air.

Refer the following you tube video links for positive displacement pumps

1. https://www.youtube.com/watch?v=4OJTN0M1DBk
2. https://www.youtube.com/watch?v=ySbtksESFUc

1.3 Irrigation pump selection

Pumps come in a wide range of shapes, sizes and types, such as centrifugal, submersible, and positive displacement pumps. They are driven by either diesel engines or electrical motors. The most commonly used pumps are single and multi stage centrifugal pumps driven by electrical motors as electricity is generally significantly more cost effective than diesel. Single stage pumps have only one stage containing a single impeller, while multi stage pumps have two or more stages and delivers higher pressures where required.

Most irrigation pumps fall within the category of pumps that use kinetic principles that is centrifugal force or momentum in transferring energy. This category includes pumps such as centrifugal pumps, vertical turbine pumps, submersible pumps and jet pumps. Most of these pumps operate within a range of discharge and head where the discharge will vary as the head fluctuates.

The second category of pumps is that of positive displacement pumps, whereby the fluid is displaced by mechanical devices such as pistons, plungers and screws.

1.4 Planning and preparing for work

1.4.1 Standard operating procedures

A standard operating procedure (SOP) is a set of step-by-step instructions compiled by an organization to help workers carry out complex routine operations. SOPs aim to achieve efficiency, quality output and uniformity of performance, while reducing miscommunication and failure to comply with industry regulations.

1.4.2 Pump station work requirement

Work requirements for monitor operation and maintenance of pump station are determined in line with specifications and instructions.

Determining work requirement is a process of identifying and arranging all necessary things by reading and interpreting the given design plans, drawings, specifications and instructions that can be used to accomplish the specific construction works.

In Pump station operational monitoring and maintenance, the following work requirement should be determined

- Location of the pump station and other components
- Timing
- Type of pumps
- Site boundary protection
- Extent of maintenance and maintenance methods should be determined from standard operating and maintenance procedures.

1.4.3 Relevant utilities and service bodies

As a part of planning and preparation work relevant utilities and service bodies which can be affected directly or indirectly by the operation and maintenance of pump station work should be consulted and involved with the planning process.

1.4.4 Hazardous materials handling

Hazardous material is any solid, liquid, or gas that can harm people, other living organisms, property, or the environment.

Rules for Safe Handling of Hazardous Materials

These rules are presented in no particular order. They are all top priorities for chemical handlers. However, feel free to rearrange them in whatever order you think is best for your workplace, your workers, and your material hazards.

The followings are rules for handling hazardous materials:

1. Follow all established procedures and perform job duties as you have been trained.
2. Always use required appropriate personal protective equipment (PPE).
3. Make sure all containers are properly labeled and that the material is contained in an appropriate container. Don't use any material not contained or labeled properly.
4. Read labels and the material safety data sheet (MSDS) before using any material to make sure you understand hazards and precautions.
5. Use all materials solely for their intended purpose. Don't, for example, use solvents to clean your hands, or gasoline to wipe down equipment.

6. Never eat or drink while handling any materials, and if your hands are contaminated, don't use cosmetics or handle contact lenses.
7. Read the labels and refer to MSDSs to identify properties and hazards of chemical products and materials.
8. Store all materials properly, separate incompatibles, and store in ventilated, dry, cool areas.
9. Keep you and your work area clean. After handling any material, wash thoroughly with soap and water. Clean work surfaces at least once a shift so that contamination risks are minimized.
10. Learn about emergency procedures and equipment.

1.4.5 Risk factors and potential hazards

1.4.5.1 Hazard identification

A **hazard** is any biological, chemical, physical or radiological agent that has the potential to cause harm. A hazardous event is an incident or situation that can lead to the presence of a hazard (what can happen and how). **Risk** is the likelihood of identified hazards causing harm in exposed populations in a specified timeframe, including the magnitude of that harm and/or the consequences.

Hazards may occur while operating and maintaining irrigation pump stations, Effective risk management, therefore, requires identification of all potential hazards, their sources, possible hazardous events and an assessment of the risk presented by each. The hazard identification step, therefore, requires the water safety plan team to consider all potential biological, physical, chemical and radiological hazards that could be associated with the irrigation system.

1.4.5.2 Hazard identification process

Identify actions necessary to eliminate or control the risks associated with the hazard. After the hazard has been identified, reviewed and assigned a risk designation, it will be necessary determine what controls (measures) necessary to eliminate, reduce or minimize the risks associated with the hazard.

To control a hazard, review all available health and safety information about the hazard such as

- regulations

- manufacturers literature
- results of testing
- MSDS(Material safety data sheet)
- controls already in place
- health policies and procedures
- industry standards
- best practices, information from reputable organizations, etc.

1.4.5.3 Types of hazard and control measures

Before identification and control of hazard in the operation and maintenance of pump station the following safety symbols should be considered

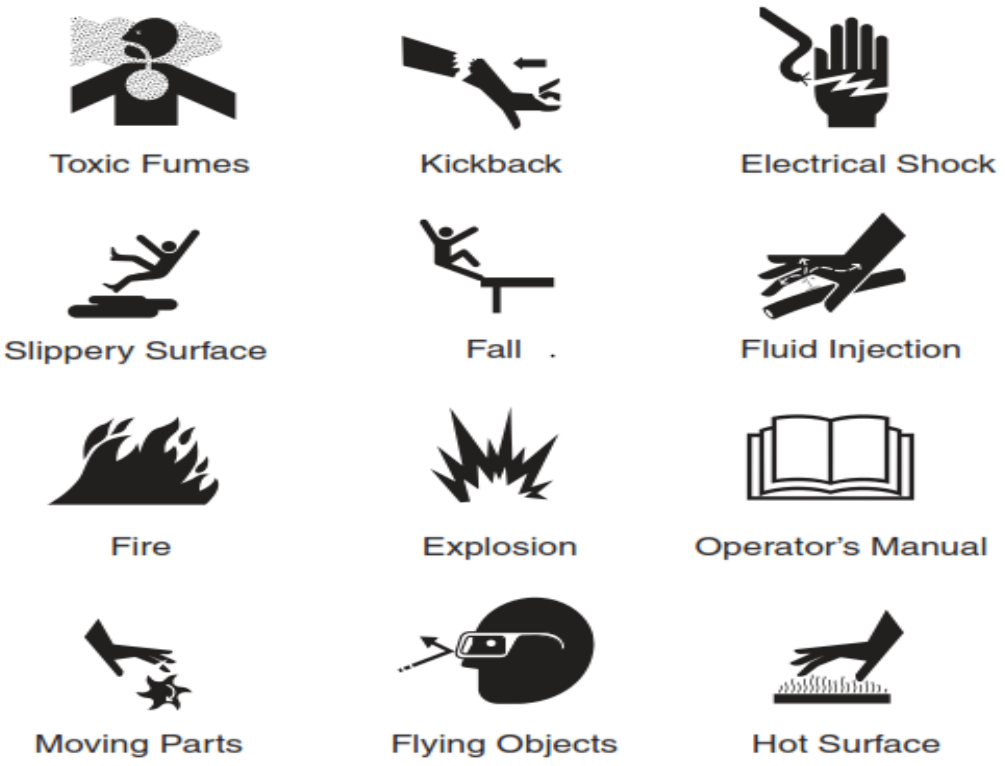


Figure 27. Safety Symbols and Meanings used in the operation of pump station

Common types of hazard in irrigation and drainage pump station area are:

1. Fire Hazards

Control measures

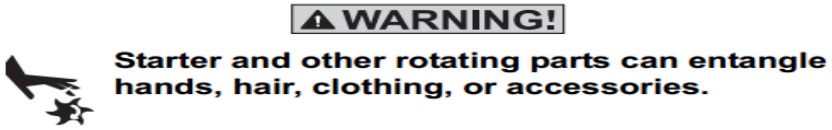
- When adding or drain fuel, turn water pump OFF and let it cool at least two (2) minutes before removing fuel cap. Loosen cap slowly to relieve pressure in tank.
- Fill or drain fuel tank outdoors.
- DO NOT overfill tank. Allow space for fuel expansion.
- If fuel spills, wait until it evaporates before starting engine.
- Keep fuel away from sparks, open flames, pilot lights, heat, and other ignition sources.

2. Fall hazard

Control measures

- Use only on a level surface.
- The area should have adequate slopes and drainage to reduce the possibility of a fall due to slippery surfaces.
- Do not use on elevated surfaces where there could be a chance of a serious fall moving part hazard

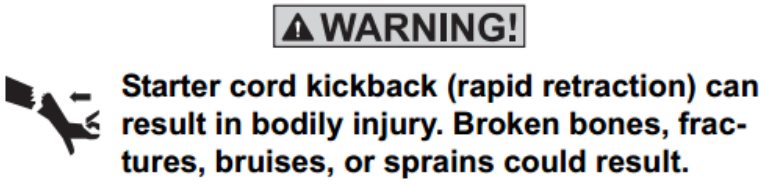
3. Rotation equipment hazard



Control measures

- NEVER operate water pump without protective housing or covers.
- DO NOT wear loose clothing, jewellery or anything that may be caught in the starter or other rotating parts.
- Tie up long hair and remove jewellery.

4. Kickback hazard



Control measures

- When starting engine, pull cord slowly until resistance is felt and then pull rapidly to avoid kickback spark hazard

5. Electric shock hazard

Control measures

- Disconnect the spark plug wire from the spark plug and place the wire where it cannot contact spark plug.

6. Splash hazard

Control measures

- Always wear safety goggles when using this equipment or in vicinity of where equipment is in use.
- Before starting the water pump, be sure you are wearing adequate safety goggles.
- NEVER substitute safety glasses for safety goggles.
- NEVER operate units with broken or missing parts, or without protective housing or covers.

Self-Check -1	Written Test

Direction I: Fill in the Blanc space item (2 points each)

Instruction: fill in the blank space from the words bank provided on the top of the questions and write your answer on the answer sheet provided in the next page:

Roto-dynamic pump	the impeller and the volute	Piston pump
centrifugal pump shaft	Hazard	Centrifugal pump
Risk	Generator	Bearings
A standard operating procedure (SOP)	positive displacement pump	pump

1. _____ is a machine used for the purpose of transferring quantities of liquids, gases and even solids from one location to another
2. _____transfers rotating mechanical energy into kinetic energy in the form of fluid velocity and pressure
3. _____ directly displaces the pumped fluid from pump inlet to outlet in discrete volumes.
4. _____ is an a type of roto-dynamic pump
5. _____ are the component parts of roto-dynamic pump
6. _____is used to transmit the torques encountered when starting and during operation.
7. A step-by-step instructions compiled by an organization to help workers carry out complex routine operations is_____.
8. _____Is any biological, chemical, physical or radiological agent that has the potential to cause harm?
9. _____is the likelihood of identified hazards causing harm in exposed populations in a specified timeframe, including the magnitude of that harm and/or the consequences.

Direction II: Matching item (2 points each)

Instruction: Match column B with column A of the following questions and write your answer on the answer sheet provided in the next page:

	A		B
1.	The rotating part that converts driver energy into the kinetic energy.	**A.**	Radial flow
2.	The pressure is developed partly by centrifugal force and partly by the lift of the vanes of the impeller on the liquid.	**B.**	Bearing housing
3.	The suction and discharge nozzles are located at the top of the case perpendicular to the shaft.	**C.**	Double- suction
4.	The pressure is developed wholly by centrifugal force.	**D.**	Mixed flow
5.	The pressure is developed by the propelling or lifting action of the vanes of the impeller on the liquid.	**E.**	Top suction Top discharge nozzle
6.	The a part of the pump that will be attached to the suction hose, sucks water from the source	**F.**	pump impeller
7.	encloses the bearings mounted on the shaft	**G.**	End suction/Top discharge
8.	The suction nozzle is at the end of, and concentric to, the shaft while the discharge nozzle is located at the top of the case	**H.**	Fall hazard protection
9.	Liquid inlet on one side.	**I.**	Diffuser
10.	Liquid inlet to the impeller symmetrically from both sides.	**J.**	suction nozzle
11	Health and safety information	**K**	Electric shock hazard control
12	Disconnect the spark plug wire from the spark plug and place the wire where it cannot contact spark plug	**L**	Timing
13	Pump station work requirement	**M**	MSDS
14	provides a connection between the head and pump bowls	**N**	The shaft and column assembly
15	Use only on a level surface.	**O**	Single- suction
		P	Turbulent flow
		Q	Axial flow

Note: **Satisfactory rating - 12 points and above** **Unsatisfactory - below 12 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Score = _____
Rating: _____

Name: _____ Date: _____

Direction I: Fill in the Blanc space questions

1. .....
2. .....
3. .....
4. .....
5. .....
6. .....
7. .....
8. ……

Direction II: Matching questions

1. .....
2. ……
3. ……
4. ……
5. ……
6. .....
7. .....
8. .....
9. .....
10. ..... .
11. .....
12. ..... .
13. ..... .
14. ……
15. ……..

Information Sheet-2	Accessing and interpreting pump operation and maintenance procedures

2.1 Operating procedures

Standard operation procedures, as being a set of written instructions that document a routine or repetitive activity followed by an organization, are documents which increase performance of the determined process, so helping coming into being processes which increase quality. They must be revised continuously to manage the same quality.

Standard Operating Procedures (**SOPs**) let you operationalize documents such as plans, regulation, compliance, and policies. SOPs distil requirements contained in these documents into a format that can be used by staff members in their work environment

2.2 Maintenance procedures

Maintenance procedures and other work-related documents should identify preconditions and precautions, provide clear instructions for work to be done, and be used to ensure that maintenance is performed in accordance with the maintenance strategy, policies and programmes. The procedures should normally be prepared in cooperation with the stockholders' and the personnel conducting activities for quality assurance and technical support. They should be technically accurate, properly verified, validated, authorized and periodically reviewed.

2.3 Planning maintenance program

The development of any program must take into consideration the maintenance tasks that need be carried out and the resources available, thereby ensuring that product quality and personnel safety standards are met. It follows that operational demand, whether they are from a service utility installation, a production line or an office environment will play a major part in reaching the decision as to what type of maintenance program requires implementation.

Planned maintenance programs are an essential weapon in a department's armory to ensure that the services it is called on in meeting its responsibilities are fully met. The traditional method of working from pieces of paper or individuals' 'own' notebooks as to

when maintenance is to be carried out or when the insurance representative is due to visit to carry out an inspection are no longer satisfactory.

Maintenance procedures that should be considered when preparing the planned maintenance program include:

1. Carrying out repairs needed when plant or equipment breaks down;
2. Predicting, from a history of breakdowns, the life expectancy of parts, bearings, etc., the tasks to be carried out and the frequency to be established;
3. Checking the condition throughout the plant of equipment, its running hours, readings of different responses (e.g. vibration, temperatures, current, etc.);
4. Monitoring the operating cycle and, where appropriate, seasonal shutdowns of plant, equipment.

2.2 Pump operation and maintenance procedures

Accessing and interpreting pump operation and maintenance procedures is important task which should be done before starting pump station operation and maintenance work. Different type of pumps and pump stations use different operation and maintenance procedure

Examples of operation and maintenance procedures for pump stations includes

- Pump start up and stopping procedures
- Pump operating procedure
- Pump pressure adjustment procedures
- Valve operating procedures
- Lockout/ tagout procedure
- Pump motor operating and maintenance procedure
- Preventive maintenance procedure
  - Pump station inspection procedures
  - Pump station cleaning procedures
- Pump station maintenance procedure
  - Removal and replacement of valves or instruments
  - Gland adjustment
  - Gland packing

Self-Check -2	Written Test

Instruction: Give shot answer for the following questions and write your answer on the answer sheet provided in the next page: (14 points)

1. Define standard operation procedure? (2 points)
2. What is the purpose of SOP? (2 points)
3. List some of the maintenance procedures that should be considered when preparing the planned maintenance program? (4 points)
4. List some examples of operation and maintenance procedures for pump stations includes? (6 points)

Note: **Satisfactory rating - 7 points and above** **Unsatisfactory - below 7 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-2

Score = _____

Rating: _____

Name: _____ Date: _____

Give short answer

1. .....
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2. .....
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3. .....
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4. .....
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Information Sheet-3	Performing site check to prevent damage to other utilities and the environment

3.1 Legislative and organisational requirements

3.1.1 Operator's manual

The operating manual is an important part of your water pump and should be read thoroughly before initial use, and referred to often to make sure adequate safety and service concerns are being addressed.

Reading the owner's manual thoroughly will help avoid any personal injury or damage to your machine. By knowing how best to operate this machine you will be better positioned to show others who may also operate the unit.

3.1.2 Organizational policy and service procedure

A policy is a written document that has been put in place so that it can be referred to as a guiding standard when performing any operation or procedure at a place of work. A policy will vary from work place to work place, but if there is no written policy in place there is no ground for management to question the actions of its workers and vise versa. The workers have no way of knowing what the correct procedure is to follow, to do satisfactory work. At the place of work there should be a policy to cover the standard operating procedures involved on running irrigation farm work.

A policy will provide the following advantages:

- It allows management a guideline on expected performance and adherence to regulations.
- It gives direction to all parties concerned.
- It sets a recognized standard that leads to quality management.

An irrigation farm should have a policy in place that sets out the standards for dealing with tools, equipment, machinery and implements and infrastructure at the place of work. This policy will cover the maintenance and servicing of tools, equipment, machinery and implements and infrastructure.

For this policy to function it will have to relate to and include other essential policies that exist at the place of work. These other policies should be some of the following:

- **Environmental policy** - to govern the impact that maintenance actions can have on the environment, such as harsh cleaning chemicals.
- **Training policy** - to govern the development of staff so that they are competent to carry out the maintenance and service functions expected of them.
- **Safety policy** - to govern the maintenance procedures within a set of safety procedures.
- **Health and safety policy** - govern the tools, equipment, machinery and implements and clothing to be worn by staff when carrying out the maintenance procedures.

The policy on maintenance and service will need to cover the following procedures:

- Procedure for reporting faulty or damaged tools, equipment, machinery and implements.
- Procedure for transferring responsibility of tools, equipment, machinery and implements.
- Procedure for following up on the transferred tools, equipment, machinery and implements.
- Procedure for ensuring that maintenance schedules are adhered to.
- Procedure to ensure that rescheduling occurs if a task is not completed according to schedule.
- Procedure for the cleaning and storage of tools, equipment, machinery and implements and implements.

3.1.3 Organizational standard

The term standard refers specifically to a specification that has been approved by a standards setting organization. The standards most frequently encountered in maintenance work will now be described under two headings; 'general-purpose standards' and 'nuclear standards'. Both standards specify systems which will maintain and assure quality; the difference is that whereas the first category is oriented to the requirements of the market place, the second is aimed more at satisfying the statutory requirements imposed by regulatory authorities particularly in respect of safety.

Federal democratic republic of Ethiopia, ministry of water resources formulate and adopt national standards and criteria for the design, installation, construction, operation,

maintenance, inspection and other activities in all water resources management undertakings.

Any water work activities should be agreed with the standards and full fill with the following conditions.

- Adopt the water sector as the responsible authority for issuance of the necessary professional certification, professional permits and licenses for consultancy, contracting, as well as manufacturing and importing related to water resources development.
- Provide the necessary legal framework for penalties commensurate with the violation of legal provisions relating to water resources.

3.1.4 Relevant federal water legislation and regulations

Relevant federal water legislation and regulations is legislative framework created for the implementation of the water proclamation and the operational of the Ethiopian Water Resources Management policy.

Development of the water policy, formulation of the national water sector strategy, the issuance of water resources management proclamation and the preparation of the 15-year Water Sector Development Programme (WSDP) beginning 2002 and in addition Ethiopia's effective involvement in the Nile Basin Initiative among others, are signs of effective governance by way of creating the ground for sustainable water resources development and management.

Focus will be given in this section for the Water Resources Management Proclamation issued in 2000(FDRE, 197/2000) and the Water Resources Management Regulations, which is due to be approved soon by the Council of Ministers before the end of 2004.

Water Resources Management Proclamation

The proclamation was issued with clear objectives and purpose to implement the, fundamental principles objectives, goal and the stipulated sectoral and cross cutting policy issues articulated in the water policy for Ethiopia.

- The proclamation has Nine Parts and 33 Articles and several sub- articles.
- The social, legal, environment, institutional and many more other related legislative provisions are treated here as appropriate and required.

- The proclamation declares, "All water resources of the country are the common property of the Ethiopian people and the state". (Federal Democratic Republic of Ethiopia (FDRE),197/2000 Article 5)
- Regarding water use priority, the proclamation states, "Domestic water use shall have priority over and above any other water uses". (FDRE, 197/2000 Article 7sub-article 1).

3.1.5 Local authority by-laws

Planning and implementing of water resources development and management, which are within the legal competence of the Regional States are further transferring down to the local administrative units at Woreda levels known as water desk. These desks are responsible for planning, budgeting, implementing and monitoring and follow-up of water projects and programmes, in their respective localities.

3.1.6 Environmental requirements

Depending on the regulation, a violation can result in both civil and criminal penalties. Ethiopia has established 16 the fundamental general policy principles that guide the equitable, sustainable and efficient development, utilization, conservation and protection of water resources in Ethiopia as it is stated in the document of Ethiopian Water Resources Management Policy. Thus, any water resources development construction should obey federal water legislation and regulations.

3.2 Performing site checks

Site checks help prevent incidents, injuries and illnesses. Through a critical examination of the workplace, inspections help to identify and record hazards for corrective action. Health and safety committees can help plan, conduct, report and monitor inspections. Site checks should be performed to prevent damage to other utilities and the environment; this should be according to legislative and organizational requirements.

Self-Check -3	Written Test

Instruction: Match column B with column A of the following questions and write your answer on the answer sheet provided in the next page:

A		B	
1.	Used to govern the development of staff so that they are competent to carry out the maintenance and service functions expected of them.	**A.**	Health and safety policy
2.	should be performed to prevent damage to other utilities and the environment,	**B.**	Site checks
3.	will help avoid any personal injury or damage to your machine	**C.**	Reading the owner's manual thoroughly
4.	to govern the impact that maintenance actions can have on the environment, such as harsh cleaning chemicals.	**D.**	standard
5.	Govern the tools, equipment, machinery and implements and clothing to be worn by staff when carrying out the maintenance procedures.	**E.**	policy
6.	specifically to a specification that has been approved by a standards setting organization	**F.**	Safety policy
7.	to govern the maintenance procedures within a set of safety procedures.	**G.**	Training policy
8.	It allows a consistency in performance towards maintenance and service	**H.**	Environmental policy

Note: **Satisfactory rating - 8 points and above** **Unsatisfactory - below 8 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-3

Score = _____

Rating: _____

Name: _____ Date: _____

Matching questions

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

Information Sheet-4	Selecting and checking equipment to meet safety requirements of task

4.1 Selecting and checking equipment

Before the operation and maintenance of irrigation pump station equipment used for operation and maintenance should be selecting and checking to meet safety requirements of task in addition personal protective equipment should be fitted and used accordingly.

4.1.1 Hand and power tools

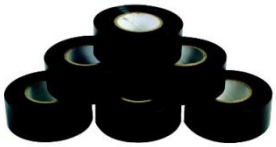
A **hand tool** is any tool that is powered by hand rather than a motor. A **power tool** is a tool that is actuated by an additional power source and mechanism other than the solely manual labour used with hand tools.

Example of hand and power tools are wrenches, pliers, cutters, striking tools, struck or hammered tools, screwdrivers, vises, clamps, snips, saws, drills and knives etc.

Power tool/equipment: cutting tool, treading tool, drilling tool, grinding tool, pumps, generators, air compressor etc.

Type of tool or equipment	How is it used in irrigation?	Tips for correct use
Spanners 	• Various pump bolts and irrigation-system bolts can be fastened or loosened with this.	• Use the correct size for the correct sized bolt. • Remember-clockwise turning fastens; while anti-clockwise turning loosens. • Never over-tighten-it will strip the bolts.
Pipe wrench 	• Used to tighten and loosen pipe couplings. • It is also used to grip round edges to enable other turning / loosening / tightening actions.	• Open the spanner before placing it on the area and then close it to size.
Shifting spanner	• Very similar to regular spanners, except that it	• Open the spanner before placing it on the area and

	provides you the option to use one tool instead of many different sized ones.	then close it to size.
Pliers 	• Cutting wire and stripping outer coatings off electrical cable. • It is also used to grip screws or pipes etc to enable other turning / loosening / tightening actions.	• Place the wire between the cutting edges where it has to be cut and close the tool to cut through the wire. • Some pliers have ridges on the front of the blades that allow stripping of outer electrical cable.
Binding wire – thick and thin 	• Used to fix couplers onto polyethylene pips. • Also used to fix polyethylene pipes to trellis systems.	• Use wire cutters to cut the wire and pliers to twist it tight around the couplers. • Flatten any pieces of wire that stand upright to avoid injury.
Wire cutters 	• Cut wire and sometimes equipped with wire stripping areas to remove the outside of electrical wiring.	• Cut through wire of the correct thickness and grade with the correct wire cutter.
Stanley knife 	• Cutting plastic pipe.	• Retract the blade when it is not in use.
Hammers	• To nail nails or hooks into	• Hammer in nails by looking

	walls or wood (small hammers). • zTo level tiles (rubber hammers). • To break down walls and concrete structures (sledge hammers).	at the nail and not focusing on the hammer head. • It is essential to use the correct hammer for the correct job.
Teflon tape 	• Secure the seal where the pipe and the couplings meet.	• Wind the tape around the thread of the coupling area and then fix the pipe to it.
Screwdriver flat tip + Phillips 	• Tighten or loosen screws of different sizes.	• Straight screwdrivers tighten or loosen screws with a straight edge while Philips screwdrivers(“star”) tightens screws with cross-sections. • Some screwdrivers are magnetic and will hold the screw to the tip of the screwdriver.
Insulation tape 	• Insulating electrical wiring.	• Wind the insulation tape around areas where electrical cables have been fixed or extended.
Bucket 	• Mixing chemicals. • Transporting liquids. • Holding ingredients.	• Use buckets for a specific purpose only. Do not use waste buckets for storage. • Use specific buckets for mixing specific chemicals.

Chemicals 	• Agro-chemicals are used as herbicides, pesticides and fertilizers and some soluble kinds can be applied through the irrigation system. • Cleaning chemicals are used to clean areas, surfaces and the inside of irrigation lines.	• Use MSDS.
Grease (pictures of different grades) 	• Apply to moving parts and bolts to prevent wear on machinery and moving parts.	• Grease parts correctly and according to a maintenance schedule. • Avoid getting grease on or inside parts or pipes of the irrigation system. • Never apply grease while a machine is running.
Grease gun 	• Apply grease to specific bolts or parts of equipment and moving parts of pumps.	• Fill the gun with the appropriate amount of grease and clean it out after use.
Hose Clamps 	• Tighten parts, couplings onto Irrigation lines.	• The clamp is designed with a screw that is tightened. • Be careful not to over tighten the clamp to prevent it cutting into the pipes underneath or damaging the coupling.

4.1.2 High pressure cleaning equipment

Blower is equipment or a device which increases the velocity of air or gas when it is passed through equipped impellers. They are used to remove dust particles from pump.

Figure 27. Blower

4.1.3 Lifting equipment

Lifting and winching equipment is a general term for any equipment that can be used to lift loads. This includes jacks, rotating screws, gantries, A frames, gin poles, shear legs, sheer leg, windlasses, lifting harnesses, forklifts, hydraulic lifting pads, and cranes.

4.1.4 On- and off-road vehicles

On and off-road vehicles are considered to be any type of vehicle which is capable of driving on and off paved or gravel surface. It is general characterized by having large tires with deep, open treads, a flexible suspension, or even caterpillar tracks.

Off-roading is the activity of driving or riding a vehicle on un surfaced roads or tracks, made of materials such as sand, gravel, riverbeds, mud, snow, rocks, and other natural terrain.

4.1.5 Portable pumps

Portable pumps are essential tools for modern fire-fighters. .Petrol engines are generally lighter than diesels and are preferred for portable fire pumps.

Figure 28. Portable pump

4.1.6 Communication equipment

A communication device is a hardware device capable of transmitting an analog or digital signal over the telephone, other communication wire, or wirelessly.

4.1.7 Gas detection equipment

A gas detector is a device that detects the presence of gases in an area, often as part of a safety system. This type of equipment is used to detect a gas leak or other emissions and can interface with a control system so a process can be automatically shut down.

4.1.8 Rescue equipment

In a high-hazard industry like construction, safety is an investment that provides real benefits for workplace illness and injury. Having measures in place to reduce risk and increase wellbeing are worthwhile investment because they will lower the number of days lost due to workplace illness/injury, increasing your overall productivity. Equipment's that are designed for purpose of safety in construction industries are called rescue equipment.

4.1.9 Appropriate personal protective equipment

All PPE clothing and equipment should be of safe design and construction, and should be maintained in a clean and reliable fashion. Employers should take the fit and comfort of PPE into consideration when selecting appropriate items for their workplace. PPE that fits well and is comfortable to wear will encourage employee use of PPE.

Most protective devices are available in multiple sizes and care should be taken to select the proper size for each employee. If several different types of PPE are worn together, make sure they are compatible. If PPE does not fit properly, it can make the difference between being safely covered or dangerously exposed. It may not provide the level of protection desired and may discourage employee use.

The various types of PPE used for the operation and maintenance of irrigation pump stations are:

Head protection shall be worn whenever there is a danger of falling objects. Types of head protection include:

- safety helmets & caps
- hats & hoods

Figure 29. Head protection

Eye Protection shall be worn when there is risk of projectiles into the eye or face. Types of eye protection include:

- safety spectacles
- goggles – laboratories, workshops,
- shields
- visors

Figure 30. Eye protection

Body & Skin Protection shall be worn when there is remaining risks in the environment. Types of body and skin protection include:

- Protective Clothing
- Sunscreen & insect repellent

Figure 31. Body and skin protection

Hand Protection shall be worn to protect the operator from contact with hazardous substances. Types of hand protection include:

- Special gloves - wrist or elbow length
- Cotton, rubber
- PVC & leather

Figure 30. Hand protection

Foot protection shall be worn wear there is a risk of objects dropping onto feet, or slip hazards present. Types of foot protection include:

- Steel capped boots
- Non slip shoes
- Waterproof boots

Figure 31. Foot protection

Hearing protection shall be worn where there is risk of noise induced hearing loss, also refer to Swinburne's Noise Procedure. Types of hearing protection include:

- Ear plugs
- ear muffs
- Helmets

Figure 31. Ear protection

Respiratory protection shall be used when exposure to the work atmosphere may be injurious to health. Types of respiratory protection include:

- face masks
- Half face respirators
- air filter units
- Self-contained breathing apparatus

Figure 32. Respiratory protection

Fall Protection shall be used where a risk of falling is present. Types of fall protection include:

- Belts & harnesses
- Lanyards & pole straps

Figure 33. Fall protection

Self-Check -4	Written Test

Direction I: Multiple Choice Questions (2 points each)

Instruction: Choose the best answer of the following questions and write your answer on the answer sheet provided:

1. Any tool that is powered by hand rather than a motor is
   A. Hand tool
   B. Power tool
   C. Pump
   D. Generator
2. Select the power tool
   A. Hammer
   B. Screwdriver
   C. Pliers
   D. Pump
3. Select the lifting and winching equipment
   A. jacks
   B. Rotating screws
   C. gantries
   D. All
4. Identify the communication equipment
   A. Pump
   B. Telephone
   C. Hammer
   D. goggle
5. Select the eye protection equipment
   A. goggles
   B. safety helmet
   C. safety hat
   D. glove

Direction II: Matching item (2 points each)

Instruction: Match column B with column A of the following questions and write your answer on the answer sheet provided in the next page:

	A		B
1.	shall be worn wear there is a risk of objects dropping onto feet, or slip hazards present	**A.**	face masks
2.	shall be worn where there is risk of noise	**B.**	Steel capped boots
3.	shall be used when exposure to the work atmosphere may be injurious to health.	**C.**	ear muffs
4.	shall be worn to protect the operator from contact with hazardous substances.	**D.**	Gloves
5.		**E.**	Very similar to regular spanners, except that it provides you the option to use one tool instead of many different sized ones..
6.		**F.**	Various pump bolts and irrigation-system bolts can be fastened or loosened with.
7.		**G.**	Used to tighten and loosen pipe couplings
8.		**H.**	Cutting wire and stripping outer coatings off electrical cable. It is also used to grip screws or pipes etc to enable other turning / loosening / tightening actions.
9.		**I.**	Used to fix couplers onto polyethylene pips. Also used to fix polyethylene pipes to trellis systems.

10. 

11 

12 

J. Apply grease to specific bolts or parts of equipment and moving parts of pumps.

K. Tighten or loosen screws

L. Cut wire and sometimes equipped with wire stripping areas to remove the outside of electrical wiring.

Note: **Satisfactory rating - 14 points and above** **Unsatisfactory - below 14 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-4

Score = _____

Rating: _____

Name: _____ Date: _____

Direction I: Multiple Choice Questions

1. .....
2. .....
3. .....
4. .....
5. .....

Direction II: Matching questions

1. .....
2. .....
3. .....
4. .....
5. ..... .
6. .....
7. ..... .
8. ..... .
9. …….
10. …….
11. …….
12. ……..

Information Sheet-5	Handling, using and storing chemicals

5.1 chemicals used in irrigation pump station

While operating and maintain irrigation pump station different type of chemicals are used. The various types of chemicals used is:

5.1.1 Cleaning chemicals

Cleaning agents are substances (usually liquids, powders, sprays, or granules) used to remove dirt, including dust, stains, bad smells, and clutter on surface. Water, the most common cleaning agent, which is a very powerful polar solvent. Examples of cleaning chemicals includes: Soap or detergent, Ammonia solution, Calcium hypochlorite (powdered bleach), Citric acid, Sodium hypochlorite (liquid bleach), Sodium hydroxide (lye) and Acetic acid (vinegar).

5.1.2 Lubricating chemicals

Understanding proper bearing lubrication procedures is critical to ensuring long-term, trouble-free performance. Lubrication is the action of applying a substance such as oil or grease to moving metallic part to minimize friction, wear and tear and allow smooth motion.

Fundamentals of lubrication

For applications at a typical irrigation system, the majority of applications will be divided into three categories. These are;

- Oils
- Greases

Oils

Oils are by far the most important of all products used on site. They are formulated with specific base stocks and additive packages to perform to a given level.

It provides, in all cases a fluid wedge between moving parts (ie bearings, gears, slides) that are in relative motion.

To explain the makeup of various oil lubricants we must separate their individual components and discuss them.

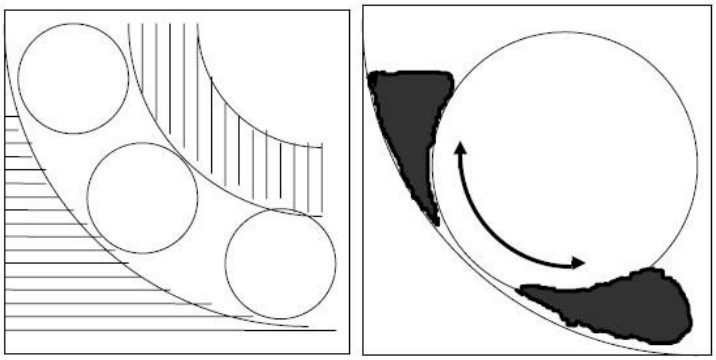
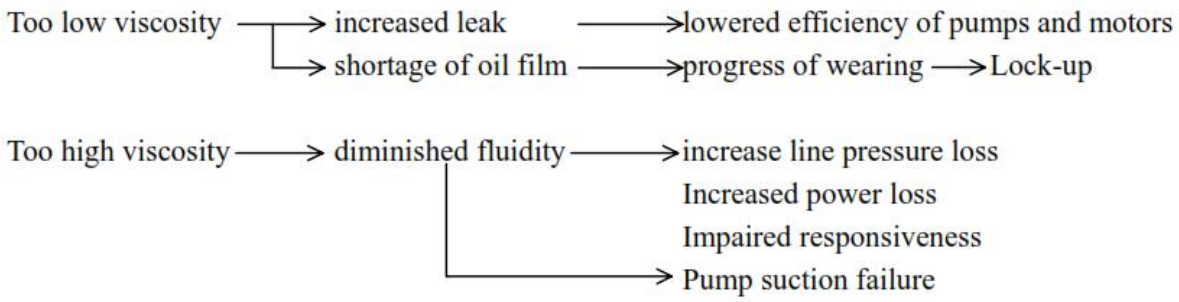


Figure 34. Bearing Cross Section Figure 35. Lubricant Wedge

Viscosity

The viscosity of a fluid is its resistance to flow. Some fluids, like water, are thin and have low viscosity while others like honey are thick and have high viscosity.

Viscosity changes with temperature; as fluid warms up it flows more easily



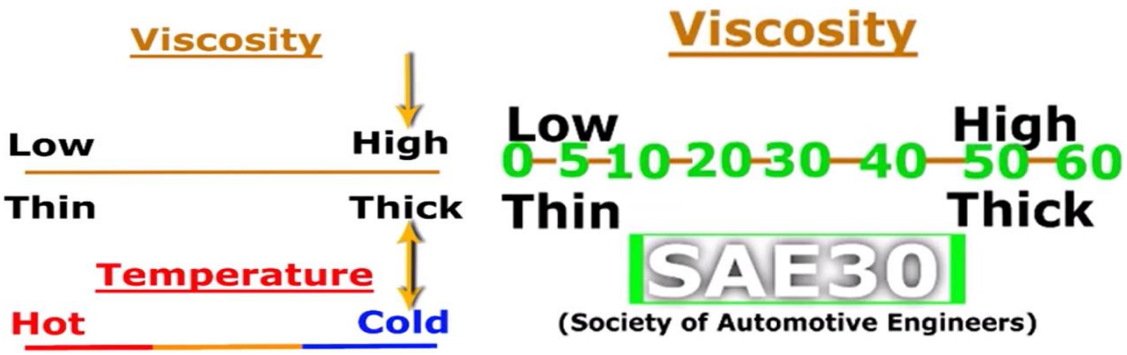


Figure 36. Relation between temperature and viscosity

Viscosity grade

SAE Designation of hydraulic oils by viscosity. The Society of Automotive Engineers (SAE) established a viscosity grading system for oils. According to the SAE viscosity grading system all oils are divided into two classes:

- monograde
- multigrade

Monograde oils

Monograde hydraulic oils are designated by one number (10, 20, 30, 40, etc.). The number indicates a level of the oil viscosity at a particular temperature. The higher the grade number, the higher the oil viscosity. Viscosity of hydraulic oils designated with a number only without the letter “W” (SAE 10, SAE 20, SAE 30 etc.) was specified at the temperature 212°F(100°C). These oils are suitable for use at high ambient temperatures. Viscosity of hydraulic oils designated with a number followed by the letter “W” (SAE 10W, SAE 20W, SAE 30W etc.) was specified at the temperature 0°F (-18°C). The letter “W” means winter. These grades are used at low ambient temperatures.

Figure 37. Viscosity grade

Multigrade hydraulic

Oils Viscosity of hydraulic oils may be stabilized by polymeric additives (viscosity index improvers). Viscosity of such oils is specified at both high and low temperature. These oils are called multigrades and they are designated by two numbers and the letter “W” (SAE 5W30, SAE 10W20, SAE 10W30 etc.). The first number of the designation specify the oil viscosity at cold temperature, the second number specifies the oil viscosity at high temperature. For example: SAE 10W30 oil has a low temperature viscosity similar to that of SAE 10W, but it has a high temperature viscosity similar to that of SAE 30. Multigrade hydraulic oils are used in a wide temperature range.

ISO Designation of hydraulic oils. International Standardization Organization (ISO) established a viscosity grading (VG) system for industrial hydraulic oils. According to the system hydraulic oils are designated by the letters ISO followed by a number equal to the oil viscosity measured in centistokes at 40°C (104°F): ISO VG 32, ISO VG 46 etc.

You can refer the following you tube video for multigrade oil

https://www.youtube.com/watch?v=aRvZyIPKR90

Greases

Grease is a dispersion of solid or semi solid additives (sometimes called soaps or thickeners) in the base fluid (oil plus additives). The purpose of grease is to present the lubricant to moving parts and allow the thickener to act as a sponge under pressure to release the base fluid as required by the moving parts.

A grease is (generally) made up of

- Base Oil (70% to 90%)
- Thickener (5% to 15%)
- Additives (3% to 10%)

As the base oil plus additives are the only components which are lubricants, greases are generally not as efficient as oils, as lubricants.

5.1.3 Fuel

Irrigation pump of fuel driven may use either gasoline or diesel fuel.

5.1.4 Thinners

Paint thinner is a solvent used to thin oil-based paints or clean up after their use.

5.2 Understanding safety data sheet (SDS)

An SDS (previously called a material safety data sheet) is a document containing important information about a hazardous chemical (which may be a hazardous substance and/or dangerous good) and must:

Figure 38. Material safety data sheet

Information on SDS

- Product identifier and chemical identity
- Hazard(s) identification
- Composition and information on ingredients, in accordance with Schedule
- First-aid measures

- fighting measures
- Accidental release measures
- Handling and storage, including how the chemical may be safely used
- Exposure controls and personal protection
- Physical and chemical properties
- Stability and reactivity
- Toxicological information
- Disposal information
- Transport information
- Any other relevant information.

5.1 Handling, using and storing chemicals

Different types of chemicals are used in the operation and maintenance of pump station so careful handling, using and storing chemicals according to manufactures manual and organizational requirements should be the operators responsibility.

Using oil lubricants

Oil velocity varies with average environmental temperature. Select engine oil with proper velocity using the chart below in accordance with your regional environmental temperature.

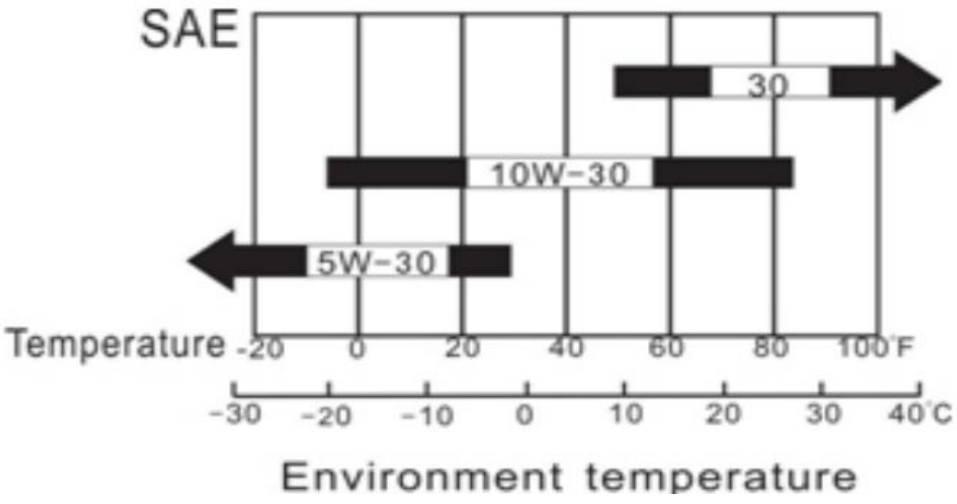


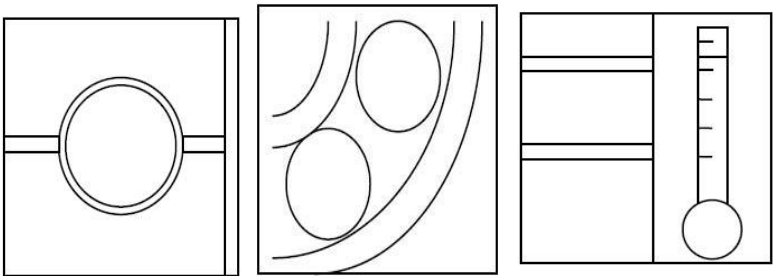
Figure 39. Effect of environmental temperature on viscosity grade

Using grease lubricant

Greases are used when oil cannot adequately stay in place due to design considerations of the equipment. They may also be used when it is desirable to;

- Seal out contaminants
- Prevent lubricant squeeze out

- Resist high temperatures



Seal Out Contaminants Resist Squeeze Out Resist High Temp

Figure 40. Using grease

Safe storage of chemicals

Chemicals must always be stored in a safe place with similar type chemicals. You should never store chemicals with food items.

Most chemicals will belong to a specific category and you need to make sure that only chemicals from the same category are stored together. If you're not sure what category a chemical belongs to, always check its label, or refer to its SDS. Categories might include:

	**Corrosive chemicals** **Chemicals such as acids can corrode substances. They can also react violently and explosively if they come into contact with other types of chemicals.**
	**Toxic chemicals** **These chemicals are poisonous and can kill you if it comes into contact with your skin, if you accidentally breathe it in, or if you accidentally swallow it.**
	**Flammable chemicals** **Chemicals such as methanol, ethanol and kerosene are very flammable and need to be kept away from heat and substances that might cause them to ignite or explode. In most workplaces, flammable chemicals are stored in a special cupboard or cabinet that has been specially designed for them.**
	**Oxidising substances** **Oxidising chemicals quickly and easily react with other chemicals. Because of this, they should only be stored with other oxidising chemicals.**

Many chemicals come with a 'Used by' date. After this date, the chemical will lose its strength. Make sure you check the 'Use by' date of chemicals before using them to find out if the chemical will still work.

A good chemical storage area should have:

- good ventilation (vents in the walls, ceiling, or open windows) to keep the store cool and prevent the build up of fumes or gases
- solid walls and roof to protect the contents of the store from wind and rain
- solid and water-proof floor so that spills don't soak into the earth and pests can't dig their way in
- good lighting so you can see what you're doing in the store
- shelves or cabinets for storing items that should not be stored together
- cloths and sponges nearby to clean up spills
- a water supply and hose nearby for clean up
- personal protective equipment such as gloves, aprons and respirators outside so that these can be worn before you enter the store
- a lock on the door

Safe Handling of chemicals tip

- Prevent the buildup of hazardous concentrations, use and store products only as directed and only use them for the right application.
- Always wear eye protection (safety goggles or a face shield) and other personal protective equipment as identified on Safety Data Sheet (SDS) when using hazardous chemicals.
- Avoid skin contact with gasoline
- Understand the properties and hazards of acids and flammable liquids in use and ensure they are properly stored in accordance with safety standards.
- Use proper ventilation when working with chemicals to avoid inhalation hazards

You can refer the following you tube video for chemical lubrication

1. https://www.youtube.com/watch?v=TC57XMMSRqY
2. https://www.youtube.com/watch?v=aaxax5idlJ0
3. https://www.youtube.com/watch?v=grfLkzjyc-o

Self-Check -5	Written Test

Instruction: Match column B with column A of the following questions and write your answer on the answer sheet provided in the next page: (2 points each)

A		B	
1.	Avoid skin contact with gasoline	**A.**	10W20
2.	Lubricating chemicals	**B.**	Chemical identity of chemicals
3.	Too low viscosity	**C.**	Flammable chemicals
4.	Too high viscosity	**D.**	Oil and grease
5.	Monograde oil	**E.**	Gasoline
6.	Multigrade oil	**F.**	Low efficiency of pumps
7.	Good light s	**G.**	Safe handling of chemicals
8.	Information included in MSD	**H.**	SAE 10
9.	Methanol, kerosene	**I.**	Good chemical storage
10.	Pump fuel	**J.**	Pump suction failure

Note: **Satisfactory rating - 10 points and above** **Unsatisfactory - below 10 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-5

Score = _____

Rating: _____

Name: _____ Date: _____

Matching

1. .....
2. .....
3. .....
4. .....
5. .....
6. .....
7. .....
8. ……
9. ……
10. ……

Operation Sheet -1	Identifying workplace hazard

Procedures for identification of workplace hazard

Instruction: given a pump irrigation system.

Steps

Step 1: Visit the site, walk around the pump station area

Step 2: look at all aspects of work and include non- routine activity such as maintenance, repair, or cleaning

Step 3: look at the physical work environment, equipment, materials etc

Step 4: look at injury and incident report

Step 5: talk to other workers: they know their job and its hazard best

Step 6: look at how the work is organized or done

Step 7: look at foreseeable unusual condition

Step 8: examine the risk and take action

Step 9: make a record on your findings using the given template

Workplace Inspection Report

Inspection Location: _____ **Date of Inspection:** _____

Department/Areas Covered: _____ **Time of Inspection:** _____

Observations					**For Future Follow-up**		
Item and Location	Hazard(s) Observed	Repeat Item Y / N		Priority A/B/C	Recommended Action	Responsible Person	Action Taken	Date

Copies to: _____ Inspected by: _____

LAP Test -1	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished:** _____

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks in irrigation pump station area within 40 hours.

Task 1: Identify pump station hazards

Instruction Sheet	Learning Guide 52: operate pump stations

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Identifying and setting or adjusting pump station components according to organisational requirements.
- Carrying out routine security inspections and cleaning duties.
- Operating pump station according to organisational requirements.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Identify and set or adjust pump station components according to organisational requirements.
- Carry out routine security inspections and cleaning duties.
- Operate pump station according to organisational requirements.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 3”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2 and 3 ” in each information sheets on pages 83, 84,93 and 101.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1,2 and 3 on pages 103-111, 111-116, 116-119 and do the LAP Test on page 120”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Identifying and setting or adjusting pump station components

1.1 Identify and adjusting pump station components

Identifying and setting or adjusting pump station components according to organizational requirements should be conducted prior to the operation and maintenance, these components includes: electrical motors, discharge and suction pipes, valves, pumps, electrical cabinets, weirs, flow meters, run time meters and wet and dry pump wells.

1.2 Pumps station components

Pump station, also called pump house in situation such as drilled wells and irrigation water, are facilitates including pumps and equipment for pumping fluids from one place to another. They are used to supply of water to canals, the drainage of low-lying land.

Pumping stations can be grouped as follows:

- for lifting water (high quantity, low pressure) from a well;
- for pumping water into a supply system, elevated water tank or water tower;
- to increase pressure.

Pumping stations for irrigation schemes may be:

a. main irrigation lift-pump stations (surface water or groundwater);
b. booster-pump stations for additional lifts in the main or branch canals;
c. drainage-pump stations.

Pump station components are discussed below

1.2.1 Pumps

Pumps are mechanical device used to move water to the desired irrigation field or other area. Pumps consist of various components, including the motor that drives the pump, the suction and delivery pipes, and various valves. Figure 42 shows the various components of a standard pump.

Figure 41. centrifugal pum

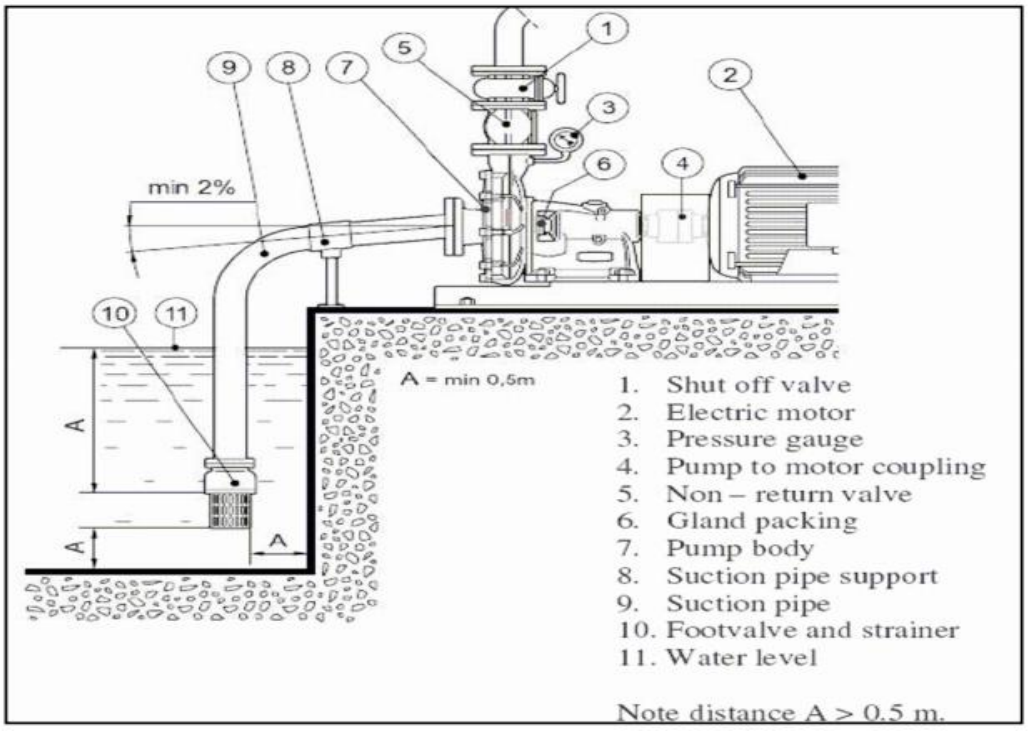


Figure 42. Centrifugal pum components

Examples of small scale irrigation pump

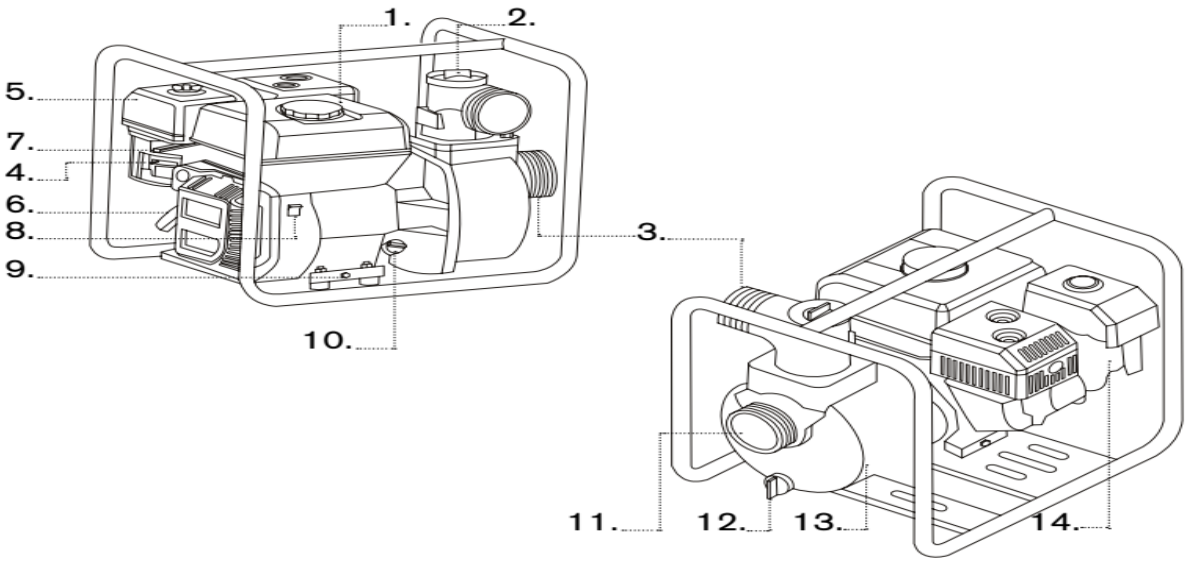


Figure 43. Centrifugal pump used forsamll scale irrigation

1. Fuel Tank	Fill tank with regular unleaded fuel. Always leave room for fuel expansion.
2. Priming Plug	Fill pump with water here to prime pump before starting.
3. Discharge Outlet	Connect discharge hose here.
4. Choke Lever	Prepares a cold engine for starting.
5. Air Cleaner	Protects engine by filtering dust and debris out of intake air.
6. Recoil Starter	Used for starting the engine manually.
7. Engine Speed Lever	Used to adjust engine speed to control pump output.
8. On/Off Switch set	This switch to “On” before using recoil starter. Set switch to “Off” to stop a running engine.
9. Oil Drain	Drain engine oil here.
10. Oil Fill Check	Add engine oil here.
11. Suction Inlet	Connect reinforced suction hose here.
12. Water Drain Plug	Remove to drain water from pump and flush internal components with clean water.
13. Pump Chamber	Be sure to fill with water before starting.
14. Fuel Shutoff Valve	Used to turn fuel supply on and off to engine

Table 1. Component part of centrifugal pump (petrol driven)

1.2.2. Filters

Filters clean and remove impurities from water that can block emitters. Various types of filters are used, most commonly sand, disc and screen-type filters.

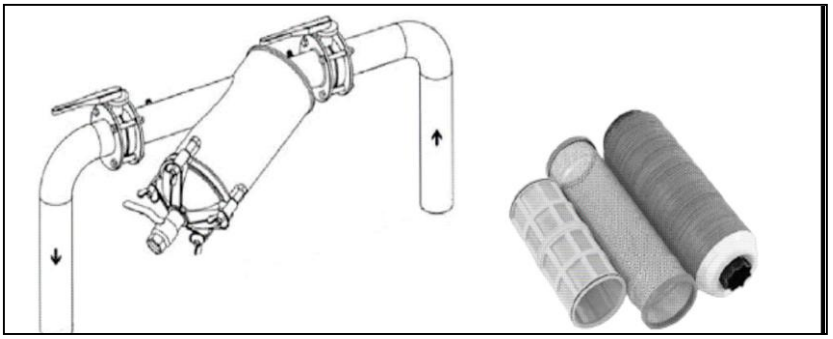


Figure 44. Inline Filter with Screen (left) and Screen and Disc Cartridges for Inline Filters (right)

1.2.3 Pipes and pipe fittings

The pipeline channels water between points, such as from the water-source to the pump, from the pump to the main lines and from the mainlines to the crops.

A wide range of pipes is available and used on farms. For main and sub-main lines u-PVC and steel pipes are normally used. In some older installations, asbestos-cement pipes are still in use. These pipes are unsuitable where acid is introduced into the irrigation water for Fertigation purposes. Polyethylene pipe (black plastic pipe) is mostly used for lateral lines, which is the name of pipelines that deliver water to the crops.

Figure 45. Galvanized steel pipe

Figure 1.46 Asbestos cement pipe

Figure 47. Plastic pipe

Figure 48. HDPE pipe

- **Suction pipe:** pipe used in the suction side of the pump
- **Discharge pipe:** pipe used in the discharge side of the pump
- **Pipe fittings**

Pipe fitting are important component of pipelines as they connect pipes and control pipe leakages. Various pipe fitting are used for distribution piping system. Choose the diameter of the fitting based on the size of pipe. These fitting are available with threading, mainly for metallic pipes. For PVC pipes, non-threaded fittings are normally used for smaller

diameter pipes. For HDPE pipe fitting special flanged fittings are available for joining pipes.

A. Socket or coupling - It is used to connect two straight lengths of pipes. The outer diameter of pipe will be equal to inner diameter of socket after threading.

B. Elbow – It connects two pipes of same diameter at an angle, normally 90 degrees.

C. Tee - it will fit two straight pipes and will have an outlet at right angle.

D. Union - It is used for joining the ends of two pipes which cannot be rotated. They are used in long stretches of straight pipes in the beginning of a pipe system and near all appliances along stop valves.

E. Reducer - It is used to connect two pipes with different size (diameter) to reduce the size of pipe. Reducer can be a socket, elbow or a tee as per required distribution network requirement.

F. Nipple - it is tubular pipe fitting, mainly in 300 mm length. It is used for extending pipeline.

G. Plug - It is used to plug the flow of water at dead ends.

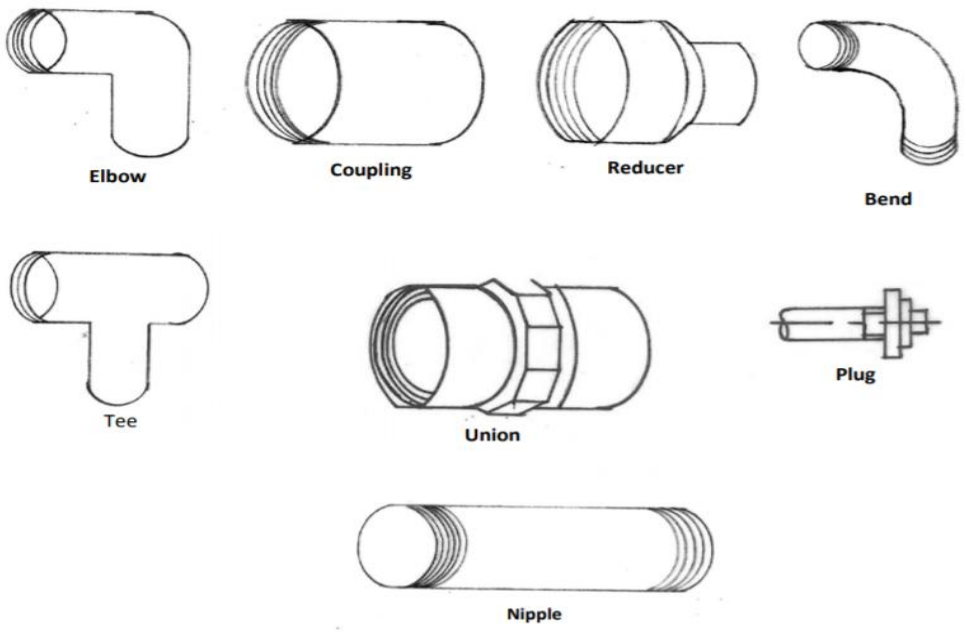


Figure 49. Pipe fitting

1.2.4 Valves

Valves control the flow of water by opening or closing, thereby allowing water through or cutting it off. Various types of valves are used. A gate valve will be installed in the suction piping so that the pump can be isolated from the line.

- **Gate and butter fly valves** are used to open or close a pipeline;

Figure 50. Butter fly valve

Figure 51. Gate valve

Refer the following you tube video link for butterfly and gate valve

1. https://www.youtube.com/watch?v=W3rSwvH3rYY
2. https://www.youtube.com/watch?v=C5ZMLWujKGs

- **Pressure control valves** are used to regulate pressure and flow rate;

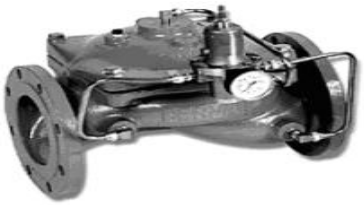


Figure 52. Hydraulic pressure control valve

Refer the following you tube video link for pressure valve

https://www.youtube.com/watch?v=JLOkj_zZp1g

- **Non-return valves** are used to prevent the reverse flow of water when the pump is switched off;

Figure 53. None return valve

- **Air and vacuum valves** are used to expel air in the pipeline and to prevent a vacuum from forming after a line is closed or the pump is switched off.

Figure 54. air and vacuum valve

Refer the following you tube video link for air valve

https://www.valvemagazine.com/magazine/sections/back-to-basics/9170-air-valves-in-piping-systems.html

1.2.5 Flow meters

Pump station water is metered for several reasons: to calculate distribution system losses by subtracting the total of meter readings from total supply, to monitoring pump efficiency, and to determine gross billings for water supplied. High rate of accuracy and wide range criteria will be desirable in most pump station flow meter applications.

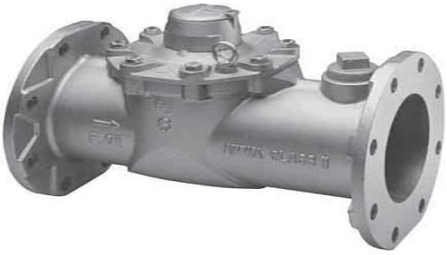


Figure 55. Water meter

Using a flow gauge or meter makes it possible to deliver the correct rate of flow to any type of nozzle, without having to calculate pressure loss due to friction or height.

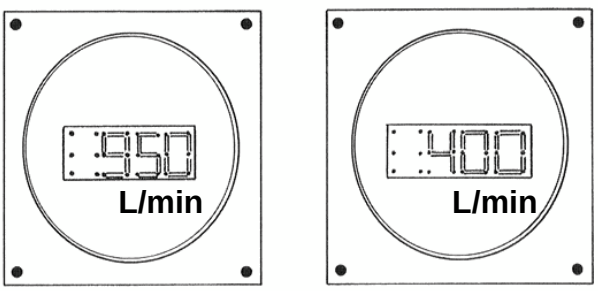


Figure 56. Flow meters showing different flow rates(digital type)

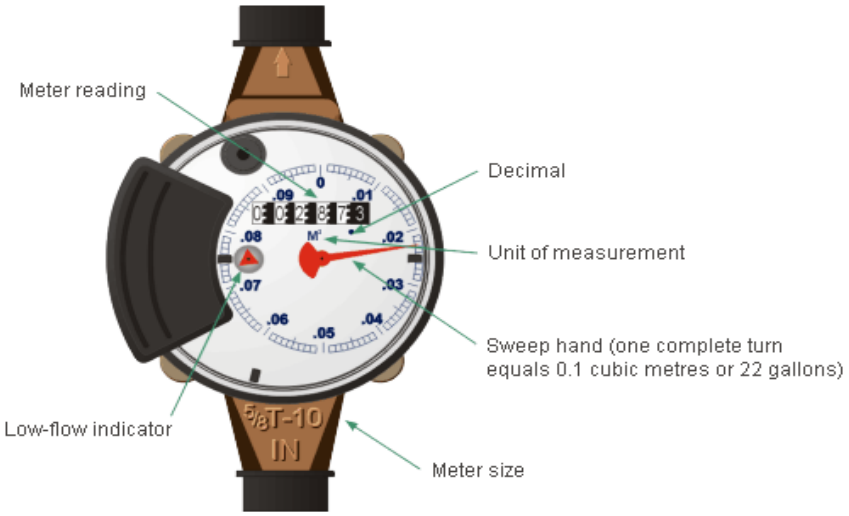


Figure 57. Analogue water meter

Reading Your Water Meter

water meter reads in cubic meters, and displays your total consumption to the nearest tenth of a cubic meter, Every 0.1 cubic meters (100 liters) of water consumed causes the sweep hand (see picture) to make one complete revolution and the measured total to increase by 0.1 cubic meters.

1.2.6 Thrust blocks

Thrust blocks are used at these locations to prevent damage to the pipe caused by unsupported pipe movement. Tees, bends, plugs, hydrants, and other appurtenances and fittings require thrust blocks to restrain the pipe.

Figure 58. Thrust block

1.2.7 Valve chamber

A room from which a valve can be operated, or sometimes in which the valve is located. Usually it is made of concrete.

Figure 59. Valve chamber

1.2.8 Pressure gauges

System pressure: It is essential to maintain a continuous positive pressure in the main at the time of transmission of water in the pipeline. Low pressure locations have to be investigated if necessary by measuring pressure with pressure gauge.

Pressure gauges are used to measure pressure in irrigation system.

	The dial indicator allows the user to easily read the pressure gauge. It consists of a face with a measurement scale on it (typically in bar or PSI, or both), a needle to indicate what pressure the water is at, a lens to protect the dial, a metal case, and a brass connection fitting.
	**What is PSI?** PSI stands for “Pounds per Square Inch” and is a unit of pressure measurement. In the UK we measure water pressure in bars, but in America they more commonly use PSI. Many water pressure gauges will have a scale including both measurements.

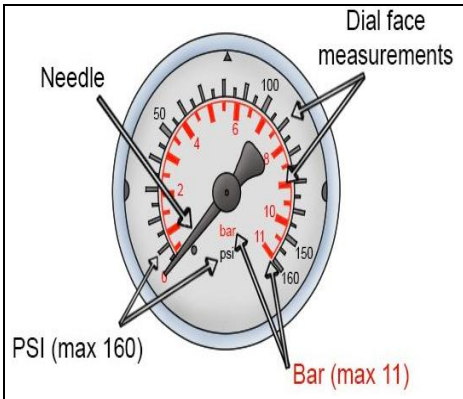
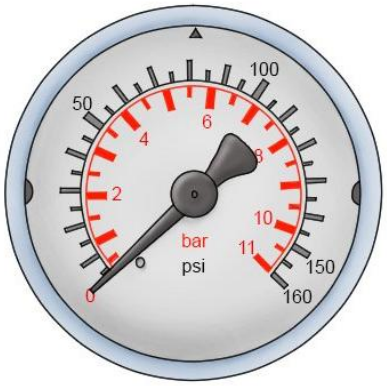
	**Water pressure gauge scale and needle** This scale and needle work together to provide an easily readable visual display that will indicate the pressure of water in a given system. On this dial indicator, bar measurements are indicated on the red scale and PSI measurements are indicated in black. The needle will move along the scale to indicate the pressure.
	**What is the maximum measurement on the scale?** There are many makes and models of water pressure gauge, with varying degrees of minimum and maximum measurements. This model has a maximum measurement of 11 bar which is typical for domestic use. The maximum measurement varies depending on the type of gauge you are using. Some industrial pressure gauges can measure in excess of 4000 bar!

Table 2. Pressure gauge

Gauges display information needed to operate and monitor the pump effectively. Gauges are sensitive pieces of equipment, care should be taken. Sudden opening or closing of valves may cause sufficient shock to damage some gauges, and should be avoided.

How do you read a pressure gauge?

You can read a pressure gauge by simply matching the needle to the number on the dial. Digital pressure gauges will read the exact PSI, and an air pressure gauge, like a tire gauge, will shoot out a little stick marked with measurements of PSI. The stick will line up with the end of the gauge so you can read the pressure.

There are two basic types of pressure gauges: analogue (dial) and digital.

1. Analogue pressure gauge

Figure 60. Analogue pressure gauges

2. Digital pressure gauge

Figure 61. Digital pressure gauge components

Refer the following you tube video links for pressure gauges

1. https://www.freshwatersystems.com/blogs/blog/how-to-use-a-pressure-gauge
2. https://www.youtube.com/watch?v=JnPSeEW-EeA&vl=en

1.2.9 Foot valve

In-Well Foot Valves: A check valve mounted in the well at the bottom of well water piping is called a foot valve and is described separately at foot valves, well piping.

Foot valves are also used on deep well installations to help protect against loss of prime in the well piping system. As you may guess, a foot valve is basically a check valve combined with an inlet strainer (visible in our page top photograph). The strainer prevents picking up large debris that could clog or jam the foot valve in its open position (or that might damage the water pump itself).

Figure 62. Foot valve

1.2.10 Prime movers

Pumps need energy as a power source. Most common pump drives for irrigation system are electric motors, petrol engine or diesel fuel.

1.3 System layout

Before starting the monitor operation and maintenance of irrigation pumps, the operator is responsible for understanding the system lay out from drawings so that the operation is facilitated and operational problem areas can easily be determined and appropriate measures to be taken.

Example of pump station for drip irrigation system is shown below.

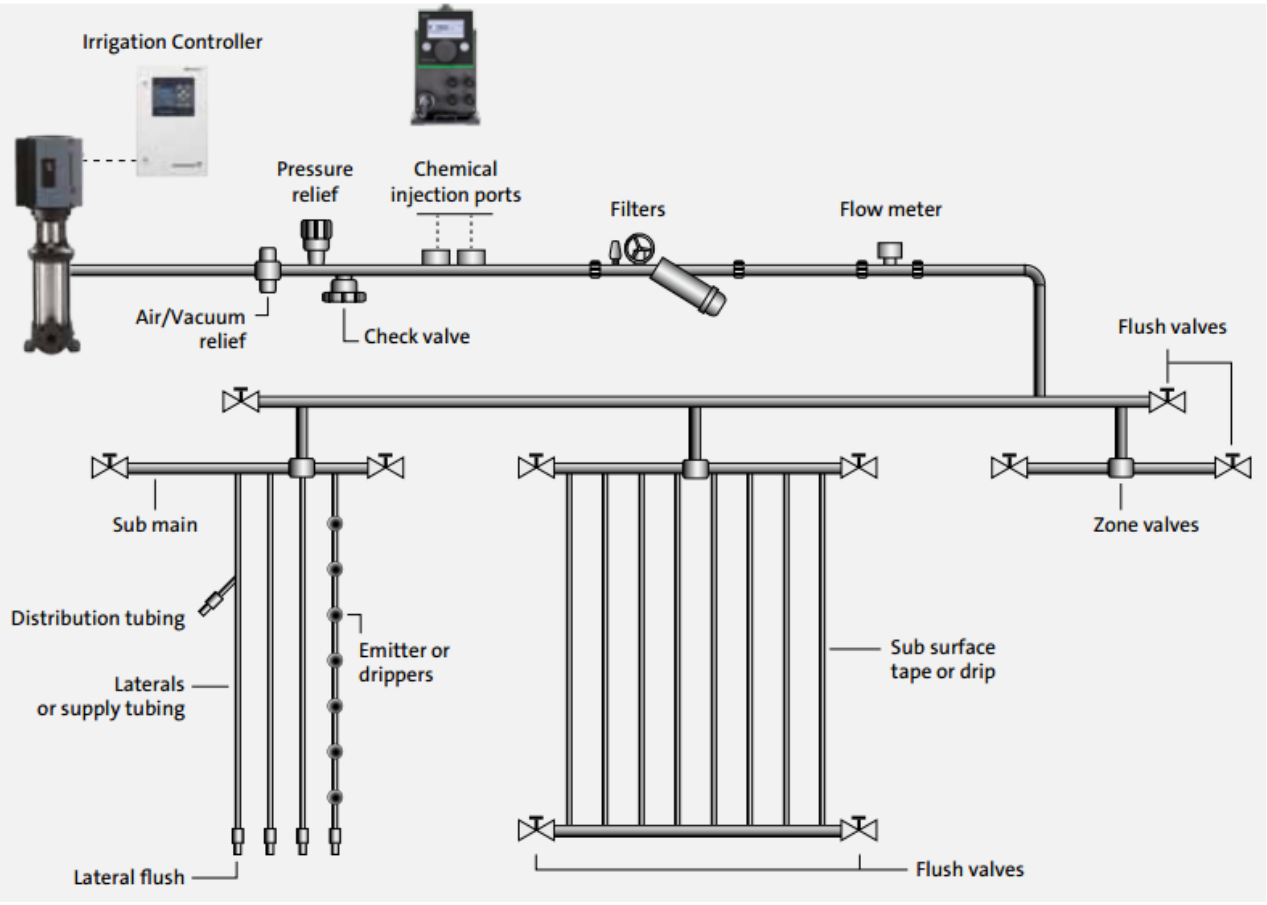


Figure 63. Drip irrigation layout

1.4 System hydraulics basics

Pressure is force per unit of area. Pressure is expressed in units of force per unit of area, usually lbs/sq. in. (psi).

Head: A term in fluid mechanics to represent the energy stored in a fluid due to the pressure exerted on its container. Measured as a length of fluid where a standard of 10m is equal to one atmosphere, or 14.7 psi.

Flow: The measurement of the liquid volume capacity of a pump. Often given in litres per minute (L/min), litres per second (L/sec) and metres cube per hour (m^3/hr).

Water Horsepower is the amount of POWER input to the water. It is related to and pump head.

Brake horsepower is the amount of power that must be applied to the pump shaft to operate the pump. It is related to water horsepower and pump efficiency.

Some of the power applied to the pump shaft is lost to turbulence inside the pump casing (volute) and friction in the pump bearings and packing. The percentage of the power input to the shaft that is actually transferred to the water is the pump efficiency.

Pressure drop: The difference in pressure between two areas of a pump, or between the inside and outside of a container.

Efficiency: The measured power out of a piece of equipment divided by the power produced by the piece of equipment. Shown as a percentage.

Relationships and Calculations

Head and flow to water horse power. The most commonly used equation is:

$$HP = \frac{Q \times H}{3{,}960}$$

Where: HP = Power applied to water in horsepower.
Q = Flow rate in gpm
H = Pump Head in ft.

Brake horsepower to water horsepower

$$BHP = \frac{WHP}{e}$$

Where: BHP = Brake horsepower (in HP)
WHP = Water horsepower (in HP
e = Pump efficiency (expressed as a decimal)

Combining these two formulas relates head and flow directly to brake horsepower. The equation is:

$$BHP = \frac{Q \times H}{3{,}960 \times e}$$

Irrigation System Head Requirement

The total system head requirements relate to the total energy or head that must be developed by a pump to overcome static lift, static discharge, good drawdown, operating pressure at discharge point and friction losses through the pumping system.

These friction losses include all the losses taking place through pumping system components including well piping, valves, fittings, nozzles, weirs, meters, suction pipe, sprinkler units and pump itself. The total system head is, therefore, site specific and a pump with a given characteristics must be chosen to meet the head-capacity requirements of the system in which the pump must operate.

Static Head (H_{stat}) It is the summation of the static discharge (hd) and the static suction heads (hs) or it is different in height between source and destination of the pumped liquid. It is independent of flow rate.

$$H_{stat} = h_s + h_d$$

Static Suction Lift (hs):

It is the difference in elevation between the static liquid level and the centerline of the pump impeller when pump is not operating. If the pump is located at an elevation below the water surface, the static lift is negative and therefore is sometimes referred as a static head. In case the pump is located right at the water surface the suction lift is zero.

Static Discharge Head (hd)

It is the difference in elevation between the centerline of the pump impeller and ultimate discharge point. In case the pump discharges directly into atmosphere at the same elevation as the delivery pipe of the pump, the static discharge head is considered zero. It is also independent of flow rate.

Drawdown

When a pump is installed in an aquifer, a cone of depression in water table develops as the pump operates. The maximum elevation between the static water table and the cone of depression at the well is called well drawdown. The well drawdown depends upon the discharge, aquifer characteristics, well radius and pumping period.

Friction head

When water flows through a pipe, the pressure decreases because of the friction against the walls of the pipe.

Therefore, the pump needs to provide the necessary energy to the water to overcome the friction losses. The losses must be considered both for the suction part and the discharge part of the pump. The magnitude of the friction head can be calculated using either hydraulic formulae or tables and graphs.

Pressure head

Except for the cases where water is discharged to a reservoir, or a canal, a certain head to operate an irrigation system is required. For example, in order for a sprinkler system to operate, a certain head is required.

Velocity head

This energy component is not shown in Figure 64. It is very small and is normally not included in practical pressure calculations. Most of the energy that a pump adds to flowing water is converted to pressure in the water. Some of the energy is added to the water to give the velocity it requires to move through the pipeline. The faster the water is moving the larger the velocity head. The amount of energy that is needed to move water with a certain velocity is given by the formula:

Operating Head

If the pump discharges into an open channel, the operating head may be considered zero. However, to operate the sprinklers, certain operating pressure is required at the discharge point which is called as operating head. This operating head may be converted into velocity head when sprinklers discharge into atmosphere. The operating head is required to attain the proper drop size and effective coverage of area.

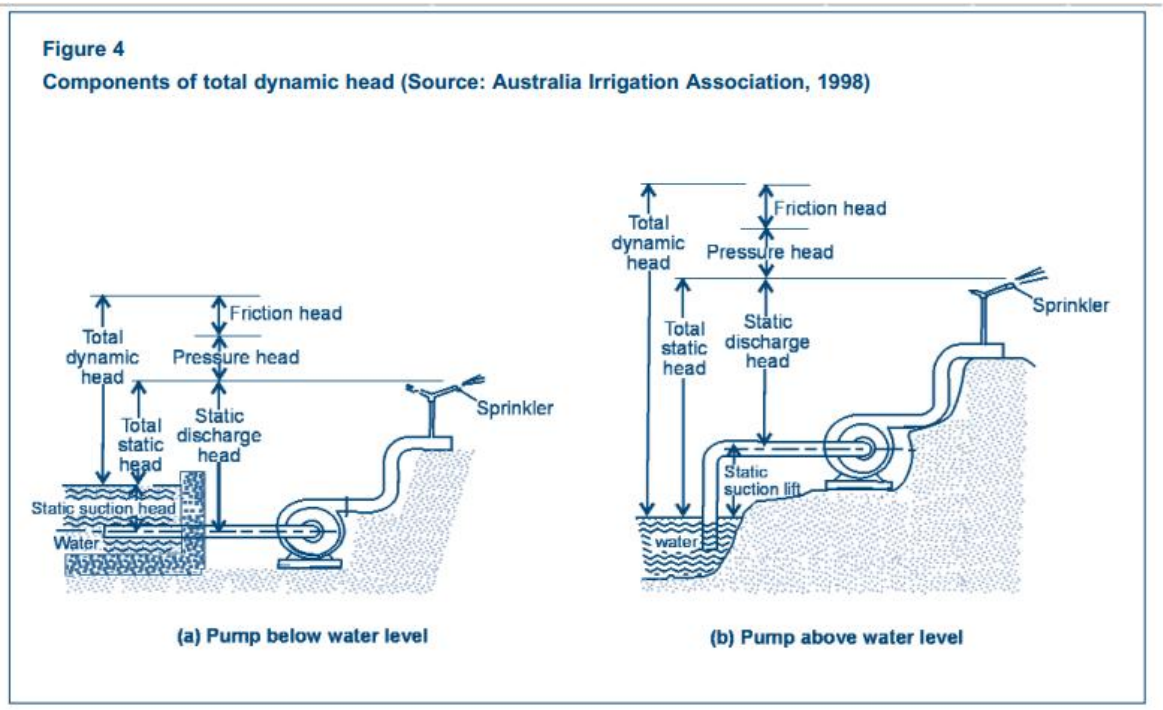


Figure 64. Components of total dynamic head

The primary function of a pump is to impart energy to the fluid. The power source is supplied by a separate unit, which may be a motor or an engine. A pump is a device, which converts mechanical energy (in case of engine) or electrical energy (in case of motor) into hydraulic energy

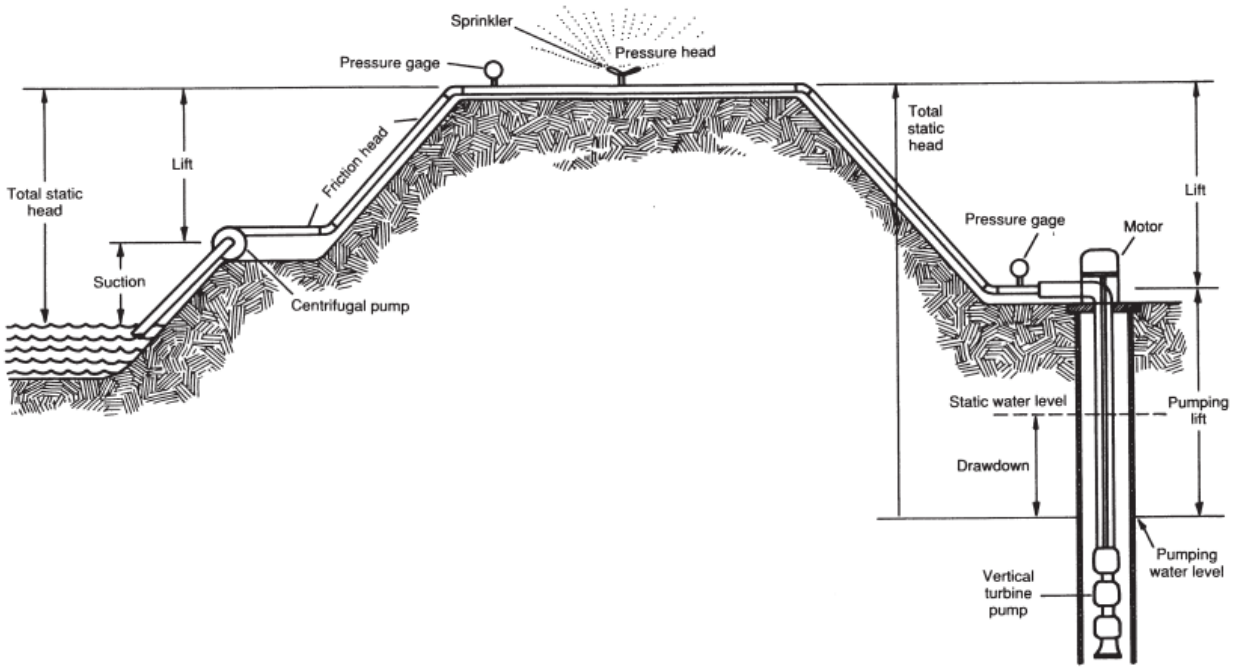


Figure 65. Components of total static head(for surface water and well water pumping)

Net positive suction head (NPSH)

The quantity used to determine if the pressure of the liquid being pumped is adequate to avoid cavitation is the net positive suction head (NPSH).

The net positive suction head available ($NPSH_A$) is the difference between the pressure at the suction of the pump and the saturation pressure for the liquid being pumped. The net positive suction head required ($NPSH_R$) is the minimum net positive suction head necessary to avoid cavitation.

$$NPSH_A = P_a + P_{st} - h_f - P_{sat}$$

Where:

$NPSH_A$ = net positive suction head available
P_a = absolute pressure on the surface of the liquid
P_{st} = pressure due to elevation between liquid surface and pump suction
h_f = head losses in the pump suction piping
P_{sat} = saturation pressure of the liquid being pumped

Energy

According to Bernoulli's theorem, the energy at any point of the system relative to datum can be expressed as:

$$H = \frac{V^2}{2g} + \frac{P}{r} + z$$

Where

H = Total energy or head, m

$\frac{V^2}{2g}$ = velocity head, m

$\frac{P}{r}$ = pressure head, m

z = potential or elevation head, m

r= unit weight of liquid being pumped

The energy developed by the pump indicates the work done by the pump on the fluid, which may include the increase in elevation (he), pressure (hp) or velocity (hv) of the fluid being pumped. Thus, total energy or total head (H) produced by the pump may be given as:

$$H = h_e + h_p + h_v$$

Self-Check -1	Written Test

Direction I: Multiple Choice Questions (1 point each)

Instruction: Choose the best answer of the following questions and write your answer on the answer sheet provided:

6. Protects engine by filtering dust and debris out of intake air
   E. Air Cleaner
   F. Fuel Tank
   G. Pump hose
   H. Priming port
7. For main and sub-main irrigation lines ----------are normally used
   E. Copper pipe
   F. u-PVC and steel pipes
   G. lead pipe
   H. Pump
8. It connects two pipes of same diameter at an angle
   E. Nipple
   F. Elbow
   G. Reducer
   H. Plug
9. ---------- are used to regulate pressure and flow rate
   A. Pressure control valves
   B. Gate valves
   C. Butterfly valves
   D. Air valves
10. The picture is represent

   E. Water meter
   F. Pressure gauge
   G. Vacuum gauge
   H. Air valve
11. Select the correct statement
   A. Efficiency is the measured power out of a piece of equipment divided by the power produced by the piece of equipment.
   B. Static Head (H_{stat}) It is the difference between the static discharge (hd) and the static suction heads (hs).
   C. Static Discharge Head (hd) is the sum of elevation between the centerline of the pump impeller and ultimate discharge point.

D. The quantity used to determine if the pressure of the liquid being pumped is adequate to avoid cavitation is the suction head.

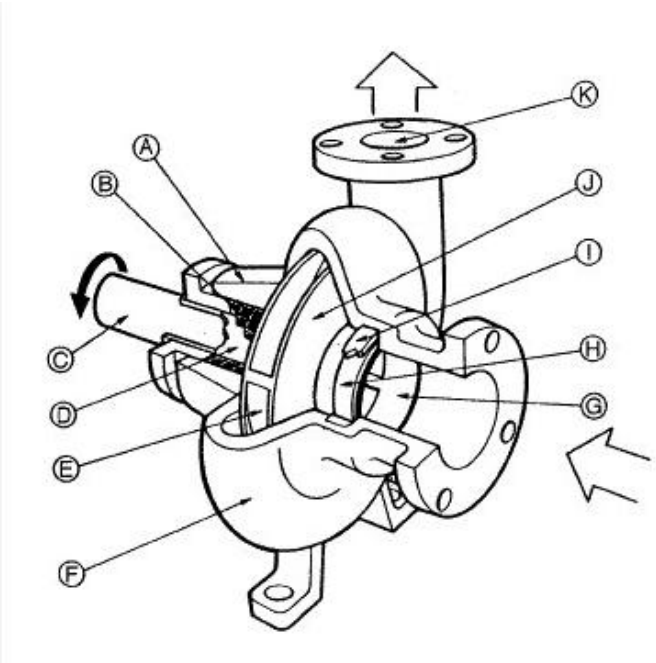
Direction II: True or false item (1 point each)

Instruction: write true if the statement is correct False otherwise of the following questions and write your answer on the answer sheet provided in the next page:

1. Identifying and adjusting pump station components should be conducted after the operation and maintenance of pump stations.
2. Pumping stations for irrigation schemes may be drainage-pump stations.
3. Fuel shutoff valve is Used to turn fuel supply on and off to engine
4. Filters clean and remove impurities from water that can block emitters.
5. Brake horsepower is the amount of power that must be applied to the pump shaft to operate the pump. It is related to water horsepower and pump efficiency.

Direction III: Short answer question

Instruction: Label the component parts of centrifugal pump of the following picture of the following questions and write your answer on the answer sheet provided in the next page: (11 points)



Note: **Satisfactory rating - 11 points and above** **Unsatisfactory - below 11 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Score = _____
Rating: _____

Name: _____ Date: _____

Direction I: Multiple Choice Questions

6. .....
7. .....
8. .....
9. .....
10. .....
11. ……..

Direction II: True false item

13. .....
14. .....
15. .....
16. .....
17. ..... .

Direction III: Short answer

A		**F**	
B		**G**	
C		**H**	
D		**I**	
E		**J**	
		K	

Information Sheet-2	Carrying out routine security inspections and cleaning duties

2.1 Routine inspection

Routine inspection refers to a simple, small-scale activities associated with and general upkeep of a building, equipment, machine, plant, or system against normal wear and tear. It requires only minimal skills or training, but it is done within a specific period of time e.g. daily weekly monthly etc. Routine inspection of irrigation and drainage system helps to avoid emergencies.

2.2 Routine inspection checklist

Routine checks are simple operation-and-maintenance inspections to verify whether the system is functioning properly, and to see whether there is any need for repairs or cleaning. Simple routine inspections can be done according to a locally suitable checklist.

Inspection checklist can be prepared as the interest of any organization but the following components can be commonly included

- Check that irrigation and drains are discharging during and shortly after rain.
- Monitor water levels in irrigation and drains
- Check whether sediments or other pollutants have accumulated in the drain, structures, or outlets.
- Look for any damage to pipe outlets and structures: a damaged outlet restricts the functioning of a drain.
- Check for proper operation pump and pump station components

Example

Inspection checklist for irrigation and drainage pump stations

Date of inspection ----------

Inspected by ----------

Inspected place/area----------

Inspection type **----------**

No	Pump station items	Asset condition
1		
2		
3		
4		

5		
6		
7		
8		

2.3 Conduct routine security inspections and cleaning duties

A suitable time schedule for routine inspections would be to start with a first inspection shortly after the system has been installed, during the first or second drainage event when the drains should be running. Further inspections could follow about once a year, a frequency which, after a few years without problems, could possibly be reduced to once every two years.

Pre-start-up inspection

Before starting up the irrigation system, a number of pre-start-up checks must be performed, being:

- Assessing water availability.
- Checking and cleaning the pump, filters and valves.

Assessing water availability

It is very important to ensure that there is enough water in the supply source, such as the river, canal, dam, pit, etc., before the pump is started. If there is not enough water in the water source the pump will suck air, which will cause cavitation, which is very destructive and can cause damage to the pump.

> ***Cavitation:*** Cavitation is caused when there are air bubbles in the water. When air bubbles hit the impeller, the section of the pump that rotates and moves the water, they implode on the impeller, which causes millions of little collisions between water and the metal surface of the impeller and thereby erodes sections of the impeller.

Cavitation is one of the greatest dangers to the pump. Cavitation can be caused by:

- The water level in the water source being too low;
- Water being lost through leakages in the suction pipe or one of its connections; or
- The filter in the inlet system being blocked or dirty;
- Defective valves that do not open properly.

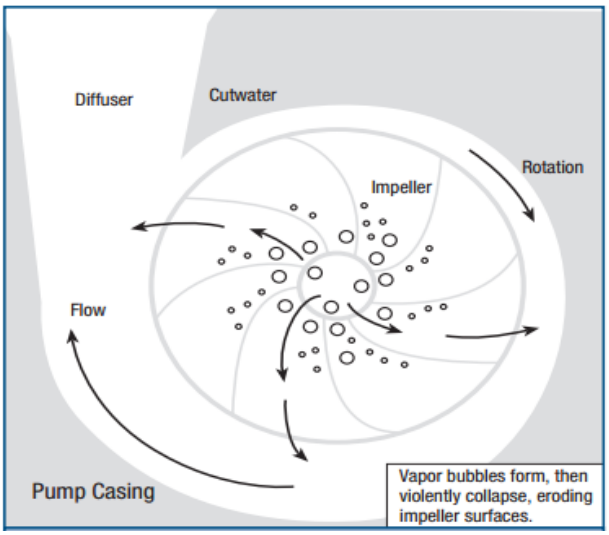


Figure 66. Cavitation in centrifugal pump

Priming: A pump is primed when the suction pipe and pump body are filled with water and there is no air on the suction side of the pump.

Self-Priming Pump

A pump that does not require priming or initial filling with liquid. The pump casing carries a reserve of water that helps create a vacuum that will lift the fluid from a low source.

All of these factors must be checked carefully as part of the pre-start-up procedure. Note that cavitation can also occur when the pump sucks air because of not being properly primed. Make sure the pump is primed properly.

Cavitation will only become evident once the pump is running, when it will show symptoms such as loss of pressure, excess noise and vibration and the pump body becoming warm. If this occurs, the pump must be switched off immediately.

Make a visual inspection of the water level before starting the pump. The water level must be above the minimum water level mark, which should be marked by the irrigation manager. If the water level is near or below this mark, do not start the pump. If the water level is too low to start the pump, or if water levels fell below the minimum water level mark while the pump was running, report it to the irrigation manager or supervisor.

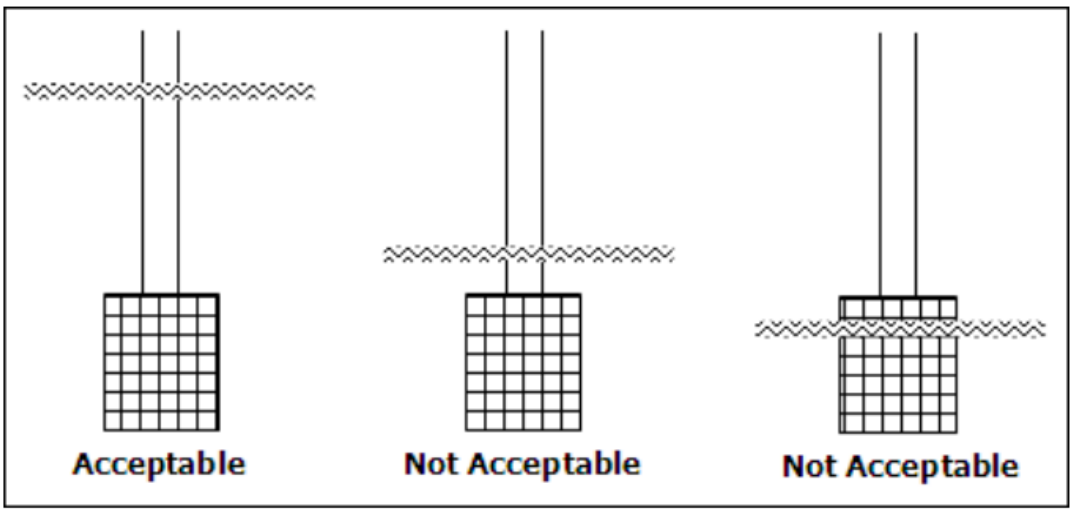


Figure 67: Acceptable Water Levels at the Suction Pipe

The picture in the middle is unacceptable, because even though the water level is above the intake, the pump will suck air as soon as it is started and the water level drops. If crops are irrigated from a borehole, a water level switch inside the borehole will prevent the pump from starting.

Cleaning Safety Procedures

Manual Cleaning

The following considerations should be addressed when manually cleaning your pump.

- Do not use toxic and/or flammable solvents.
- Lock out electrical power and shut off all air prior to cleaning equipment.
- Keep electrical panel covers closed and power off when washing equipment.

DANGER: warning
To prevent an accidental start-up the power source should be locked out using your lock and key.

- Clean up spills as soon as possible.
- Never attempt cleaning equipment while it is operating.
- Wear proper protective clothing

Checking and cleaning components

The various components of the irrigation system must be checked before the system is started. Never start the pump system to check that it is working properly, as damage may be caused to a component. A visual check of the various components is essential.

Pump

Pumps and motors run on bearings that need lubrication by either grease or oil. Failing to lubricate the pump and motor can result in a serious damage.

Bearings that are lubricated by oil have a dipstick that indicates the oil level. Before the pump is started when you check the oil level. The oil level should be between the minimum (Min) and maximum (Max) marks. If the oil level is above the Max or below the Min marks, report it immediately to the manager. In addition, when you visually check that the oil is clear. If the oil is milky, grey or black, report it immediately to the manager before starting the pump.

Where pumps and motors are fitted with grease nipples, the pump and motor must be greased regularly. Consult the manager for the intervals, as they vary between different makes of pumps and motors. Note however that some motors are fitted with sealed bearings that must not be greased. Beware of over-greasing electrical motors, as the excess grease can end up inside the motor windings and cause the motor to burn out.

Filters

Filters are used to remove solids and other debris from irrigation water. There is a filter, called a suction filter in the suction pipe before the water enters the pump. There are also filters in the delivery pipe after the pump.

It is important to ensure that the filters are working properly, otherwise:

- Pump failure can occur due to blockage of the impeller. This will happen if the suction strainer is broken or missing;
- Pipes or emitters can be blocked by debris or other solids.

The suction strainer is under water and can be checked only by removing it. This is done once a year or on instruction from the manager. At these times, inspect the strainer for damage and blockages, and clean if needed.

Reporting on the pre-start-up inspection

A pre-start-up checklist should be used to record the findings of the pre-start-up procedure. Below is an example of a pre-start-up checklist:

Pre-Start-Up Checklist

Pre-Start-Up Checklist			
Pump Station:		**Date:**	
Item	***Checked***	***Comments***	
Water Level			
Pump			
Excessive Water Oil Levels			
Flanges			
Gland Packaging Couplings			
Mountings Free Rotation			
Motor/Starter Panel Dry			
Other Comments			
Filters			
Valves Lids			
Seals Flanges			
Inline Filter (Hydraulic Valves)			
Other Comments			
Valves (Manual)			
Manual Open/Close Spindle			
Leaks			
Other Comments			
Valves (Hydraulics)			
Settings Other Damage			
Other Comments			
Checked By:		**Signed:**	

When the pre-start-up checklist has been completed it is handed to the supervisor or manager, and matters that require urgent attention is reported verbally to the supervisor.

Self-Check -2	Written Test

Direction I: Multiple Choice Questions (2 point each)

Instruction: Choose the best answer of the following questions and write your answer on the answer sheet provided:

1. ---------- a simple, small-scale activities associated with and general upkeep of a building, equipment, machine, plant, or system against normal wear and tear

   A. Routine inspection
   B. Fuel Tank
   C. Pump hose
   D. Priming port

2. Suitable time schedule for the routine inspections would be:
   A. shortly after the system has been installed
   B. during the first or second drainage event
   C. once a year
   D. All

3. Identify the pre start inspection
   A. Assessing water availability.
   B. Checking and cleaning the pump, filters and valves.
   C. Prime pump
   D. All

4. Pump failure can occur due to blockage of the impeller. This will happen if the suction strainer is broken or missing;
   A. True
   B. False

5. The following considerations should be addressed when manually cleaning your pump. Except?
   A. Do not use toxic and/or flammable solvents.
   B. Lock out electrical power and shut off all air prior to cleaning equipment.
   C. Keep electrical panel covers closed and power off when washing equipment.
   D. clean equipment while it is operating

Direction II: Short answer questions (18 points)

Instruction: Give short and precise answer for the following questions and write your answer on the answer sheet provided:

1. Draw up a detailed checklist for yourself and / or the farm on which you will be performing your practical learning of everything that has to be checked prior to starting-up the pump system on an irrigation farm. (5 points)
2. Give two reasons why filters must work properly?(3 points)
3. What could be the problem if it was not possible to prime the pump? (3 points)
4. Describe what will happen if you start the pump and the water level is too low.(3 points)
5. Describe where the water level should be.(2 points)
6. What will happen if you do not grease or oil the pump and motor? (2 points)

Note: **Satisfactory rating -14 points and above** **Unsatisfactory - below 14 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-2

Score = _____

Rating: _____

Name: _____ Date: _____

Direction I: Multiple Choice Questions

1. .....
2. .....
3. .....
4. .....
5. .....

Direction II: Short answer questions

1. ……
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Information Sheet-3	Operating pump station

3.1 Pump operation basics

Best Efficiency Point (BEP), the flow rate where a pump has its highest efficiency, is a key factor to assess whether a pump is being operated properly. Few pumps operate at their exact BEP all of the time, because process variables in a production environment are not 100 percent constant. But a pump that is properly sized for its application will maintain a flow near peak efficiency. Maintaining a flow between 80 percent and 110 percent of BEP is a good range to maximize efficiency and minimize the risk of excessive wear or pump failure.

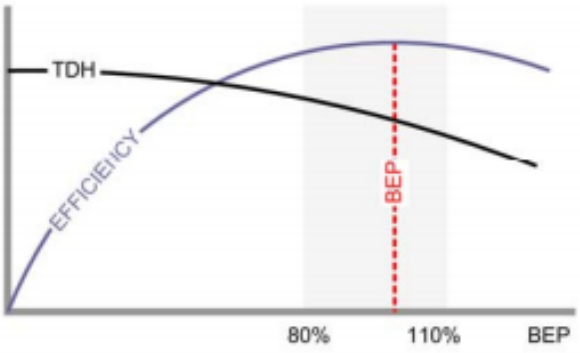


Figure 68: centrifugal pump characteristics

3.2 Environmental aspects of operation

Pumps, piping, and equipment must be protected from the weather as dictated by local climatic conditions. In cold climates pumps and piping must be protected from freezing and are usually completely housed in structures. In warm climates portions of stations may be located in outside enclosures which must provide protection from moisture and other weather related conditions. The impact of noise on the surrounding area and the need for security fencing will be considered for all stations.

3.3 Pump and pump station operation

Operation and maintenance tasks for electric pump stations are comparatively simple; those for diesel operated a little more complex. The operators must be given clear instructions on safety measures, on the methods of starting the pump motors and the way in which they must be brought into full operation. Electric motors sometimes require to be

stepped up in speed manually at a strictly controlled rate. Also canals may be damaged if all pumps come rapidly into full operation.

They must also be given a programme of irrigation quantities to be pumped i.e. 1, 2 or 3 etc. pumps to be operating. Where 24 hour pumping is not provided, account must be taken of the rate of rise and fall of canal levels in the irrigated area. It is of little use with a 12 hour pumping schedule if canals do not fill up until late in the morning and still remain full long after dark.

In case of an emergency, there must be some system for easy communication between the pump house operator and the officer in charge - either telephone or signal or runner.

Priming pumps

Priming means to fill the pump with water so that all air is expelled. If the pump is not primed, it will not be able draw water from the water source, which will result in cavitation. If the pump is fully primed, it will be able to draw and pump water. Centrifugal pumps must be fully primed in order to work properly. There are various methods that can be used to prime a pump depending on the position of the pump with respect to the water level. If the pump is above the water level, the pump can be primed using the funnel, the vacuum pump or the line pressure.

When the main line is filled with water, the line pressure can be used to prime the pump. If a non-return valve is fitted at the delivery valve, the bypass valve as well the cock valve must be opened. Air will blow from the cock valve. When water squirts from the cock valve, the pump is primed and the cock and bypass valves can be closed.

In some instances the pump won't prime, which could be due to either a leak on the suction pipe or a faulty foot valve. Report such an incident immediately to the supervisor or manager.

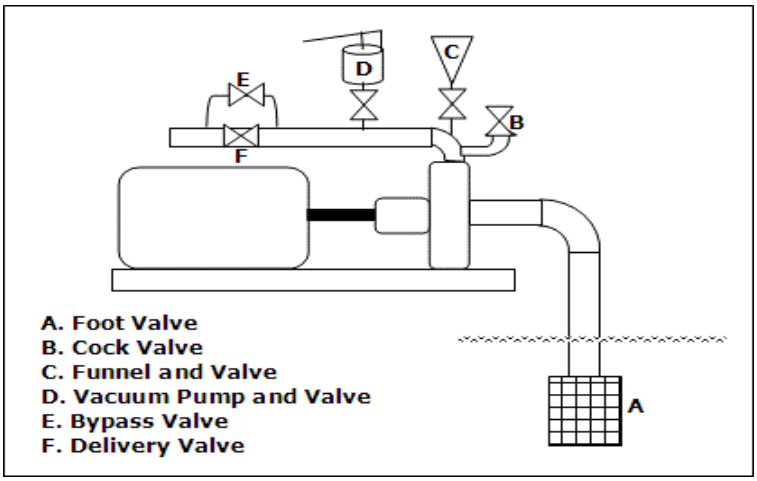


Figure 69. Pump prime configuration

Starting up and shutting down pumps

Proper starting and shutting down of pumps will ensure that the pump will operate optimally for a long time. It is very important that the delivery valve must be closed before the pump is started or shut down. If the delivery valve is open during start-up, the pump will need more energy to start, resulting in a bigger electricity bill. If the pump is shut down with an open valve, water hammer can occur, which can damage the internal parts of the pump.

Water Hammer:	Water hammer occurs when if a pump is stopped abruptly, and the column of pumped water stops and flows backwards towards the pump because of the pressure inside the pipeline.

Note that some pump installations are equipped with automated hydraulic valves. These valves open and close automatically when the pump is switched on and off.

Motor and pump working characteristics

Most pump installations are equipped with the following gauges:

- The **amp meter** is located on the electrical panel and measures the current that is used;
- The **volt meter** is located on the electrical panel and gives a reading of the voltage, e.g. 400V;
- The **pressure gauge** is located on the delivery pipe and gives a reading of the pressure in kPa or Bar;

- The **flow meter** is installed on the delivery pipe and measures the flow in cubic meters (m^3). Mechanical flow meters have a dial gauge on the meter, while electronic flow meters have a digital readout in a special panel.

Although all pump stations will not necessarily have volt and flow meters, it should at least be equipped with an amp meter and pressure gauge.

The normal readings, or norms, differ from pump to pump. The supervisor or manager should give the norms for amps, volts, pressure and flow. Actual readings are compared with the norms to establish whether the pump and motor are running optimally, and to assist with determining the pump and motor characteristics.

There are three possible scenarios:

- Amps motor = Amps norm
- Amps motor > Amps normal
- Amps motor < Amps normal

Amps motor = Amps normal

This is the normal operating condition for the pump. Note that the pressure and flow readings will also be normal.

Amps motor > Amps normal

This is referred to as an overload condition. When the control panel detects an overload, it automatically shuts down the pump.

If the pressure reading is lower than the norm and the flow is higher than normal, it means that too many valves are open or that a pipe has burst. If the pressure and flow is normal, it means that mechanical failure has occurred, for example a ceased bearing causing excessive friction. This will

be coupled with noise and vibration. The pump must be switched off and the situation reported to the supervisor or manager.

Amps motor < Amps normal

This is referred to as an under-load condition.

If the pressure is high and the flow is low, it could be that too many are valves closed, that the filter bank is blocked, or that a valve is malfunctioning or stuck. If the pressure is very

high, being near the same reading as when the valve is closed, switch off the pump as the pump will overheat due to the low flow. Report these deviations to the manager.

If the pressure and flow are low, the pump is cavitating, causing the pump to vibrate and be noisy. Switch the pump off immediately. The pump could have sucked air or have a blocked impeller or suction strainer. Report this situation to the manager.

Opening and closing pressure control valves

Pressure control valves are hydraulic valves fitted with a pilot valve and is used to regulate pressure and flow. The pilot valve is a device that regulates the pressure inside the hydraulic valves.

These valves are controlled by a 3-way valve. The 3-way valve is marked Open, Close and Auto. To open the pressure, simply turn the dial to Open and to close the valve, turn the dial to Close. To regulate the pressure, or for other automated functions, turn the dial to Auto.

Keep in mind that turning the dial to open could burst a pipe because of high pressure. The pilot should be adjusted by the supervisor or manager. Some valves are fitted with pressure points.

Possible problems

After a pump is started in the morning, it must be monitored during the day to ensure that it is running smoothly. Always check the perimeter and working characteristics of the pump as described in previous sections. Also pay attention to vibration, noise, leaks, burst pipes, smoke, sparks, fire, etc. Switch off the pump immediately if any of this should occur and report it to the supervisor or manager.

Infield valves

Hydraulic, gate or butterfly valves are used as infield valves. Hydraulic valves are opened as described in section,

Operation Mechanism Gate valve opening/closing is achieved using Hand wheel/Gear unit. Gear units are provided on valves for easier operation. Clockwise operation is for closing and counterclockwise for opening of the valve. The position of the valve can be noted using the position indicator provided on the gear unit. The number of turns will depend on the gear unit used.

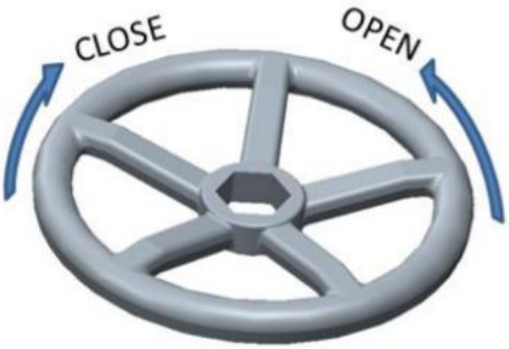


Figure 69. Gate vale valve opening and closing direction

Forcing the hand wheel, chain wheel against the stops will not provide tighter shutoff of the valve and may damage the seat faces, stem or gear unit.

Butterfly valves are equipped with a handle. Some butterfly valves are equipped with a wheel and dial. When the wheel is turned, the dial indicates if it is opening or closing.

To set the flow rate for an irrigation block, the pressure needs to be adjusted by opening or closing the valve. To reduce the pressure, close the valve more, and to increase the pressure, open the valve more. All valves under water pressure must always be opened and closed very slowly to prevent water hammer and the resulting damage.

Ball Valve

A Ball valve is a quarter-turn rotary motion valve that uses a ball-shaped disk to stop or start the flow. Most ball valves are of the quick-acting type, which requires a 90° turn of the valve handle to operate the valve. The ball valve is Smaller and lighter than a gate valve of same size and rating.

Non return valve

The **function of non-return valve** is to limit the flow of fluid through it one direction. They may be manually operated or may be automatic operated. Automatic **valves** are designed for particular pressure, when pressure (of fluid) exceeds that limit, **valve** opens allowing the fluid to flow through it

Self-Check -3	Written Test

Direction I: True or false questions (2 point each)

Instruction: Write true if the statement is correct false otherwise for the following questions and write your answer on the answer sheet provided:

1. The function of non-return valve is to limit the flow of fluid through it one Direction.
2. To set the flow rate for an irrigation block, the pressure needs to be adjusted by opening or closing the valve.
3. Butterfly valves are equipped with a handle and self operating type
4. Forcing the hand wheel against the stops of a gate valve will provide tighter shutoff of the valve.
5. Best Efficiency Point (BEP), the flow rate where a pump has its highest efficiency.
6. Proper starting and shutting down of pumps will not ensure that the pump will operate optimally for a long time.
7. Priming means to fill the pump with water so that all air is expelled.

Note: **Satisfactory rating -7 points and above** **Unsatisfactory - below 7 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-3

Score = _____

Rating: _____

Name: _____ **Date:** _____

Direction I: True or false Questions

1. .....
2. .....
3. .....
4. .....
5. .....
6. ……
7. ……

Operation Sheet -1	Performing pre-operational inspection(checks) of pump stations

Activity 1: Procedures for pre-operational inspection (checks) of centrifugal pumps

Steps

Step 1: Wear appropriate PPE

Step 2: Check for excessive water inside the pump house. If excessive water is found, try to establish where the water is coming from.

Step 3: Check the oil levels.

Step 4: Inspect the pump for leaks at flanges and leaks on the pump body. Flanges are the metal discs on the pipes that are bolted down on to the pump. A gasket is inserted between the two flanges and leakage can occur if the gasket is worn or if the flanges are not properly tightened.

Step 5: Inspect the gland packing around the pump shaft. The gland packing is the seal at the pump shaft and seals of the water inside the pump.

Step 6: Check the rubber coupling at the pump and motor shaft for signs of wear and cracks.

Step 7: Check for loose mounting bolts, which are used to attach the pump to the platform.

Step 8: Turn the pump with your hand to ensure that it rotates freely.

Step 9: Check that the motor is not wet.

Step 10: Check that the starter panel is not wet.

Step 11: Check for signs of vandalism, e.g. forced entry, missing cables, broken panels and mountings.

Activity 2: Procedures for pre-operational inspection (checks) of filters

Steps

Step 1: Check the filter valves.

Step 2: Check that the filter lids are bolted or clamped down.

Step 3: Check the lid-seal or rubber ring for cracks.

Step 4: Check flanges for leaks.

Step 5. If the filter is fitted with hydraulic valves, check the small inline filter and clean if necessary.

Activity 3: Procedures for pre-operational inspection (checks) of manual valves, being gate and butterfly filters

Steps

Step 1: Check the valves manually to see if they open and close as they should.

Step 2: On gate valves, check whether the spindle rises or drops, as this can be indication of a broken thrust washer, in which case the valve will not open or close.

Step 3: Check if the spindle keeps on rotating. This indicates a stripped nut, in which case the valve will not open or close.

Step 4: Check for leaks at the gland packing, spindle seal, flanges and casing.

Step 5: Check for signs of vandalism, such as a missing wheel or vandalized parts.

Activity 4: Procedures for pre-operational inspection (checks) of hydraulic valve

Steps

Step 1: Check to see if the 3-way valve is able to turn between open, close and auto, and return it to original setting.

Step 2: Check the rest of the valve for damage to the tubing, fittings, solenoids and wires.

Activity 5: Procedures for pre-operational inspection (checks) of engine oil level

Steps

Step 1: Wear appropriate PPE

Step 2: Place water pump on a flat, level surface

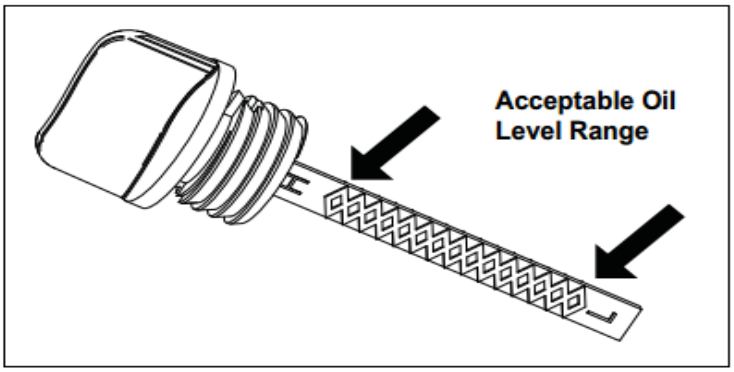
Step 3: Remove the engine oil dipstick and wipe it clean.

Step 4: Insert the dipstick into the engine oil filler hole without screwing it in.

Step 5: Remove dipstick and **check** engine oil amount.

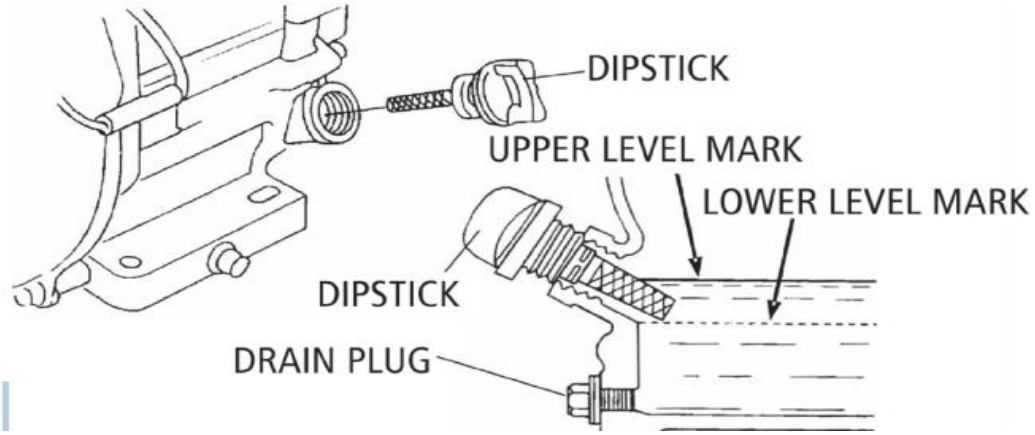
Step 6: If engine oil is below required amount, Using oil funnel, slowly pour specified engine oil up to the top of filler hole.

Step 7: Check periodically until the oil level is between “L” and “H” on the dipstick . Do not overfill.



Step 8: Replace oil fill cap/dipstick and fully tighten

Caution: Use engine oil depended on environmental temperature. Refer to Product Specification section for proper engine oil capacity.



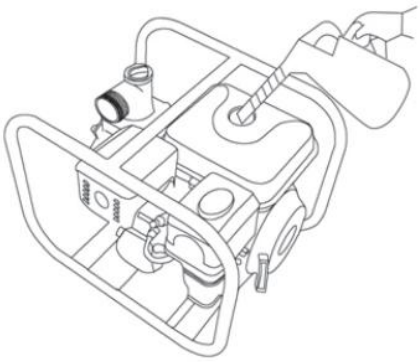
<u>Activity 6:</u> Procedures for pre-operational inspection (checks) of engine fuel level

Steps

Step 1: Remove fuel filler cap.

Step 2: Visually check fuel level within gas tank.

Step 3: If too low, add fuel. Only use specified gasoline. Unleaded gasoline is recommended. Refer to Product Specification section for fuel tank capacity



<u>Activity 7:</u> Procedures for pre-operational inspection (checks) of Air cleaner element

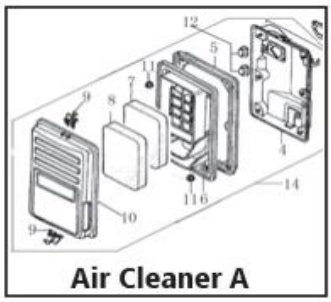
Steps

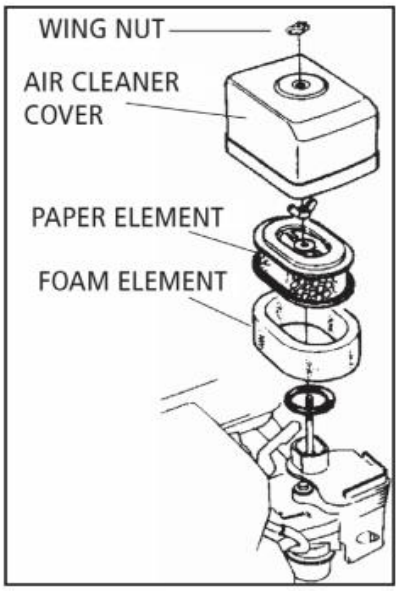
Step 1: Remove the clip (item 9 in “Air Cleaner A” below) or the wing nut (item 7 in “Air Cleaner B” below) to remove and check the air filter element.

Step 2: For sponge type air filters, wash with soap and water when contaminated. excess liquid from air filter element and allow the air filter element to dry.

For paper type air filters, replace with the correct air filter for your unit.

Step 3: Re-Install the air filter element into the air filter housing.



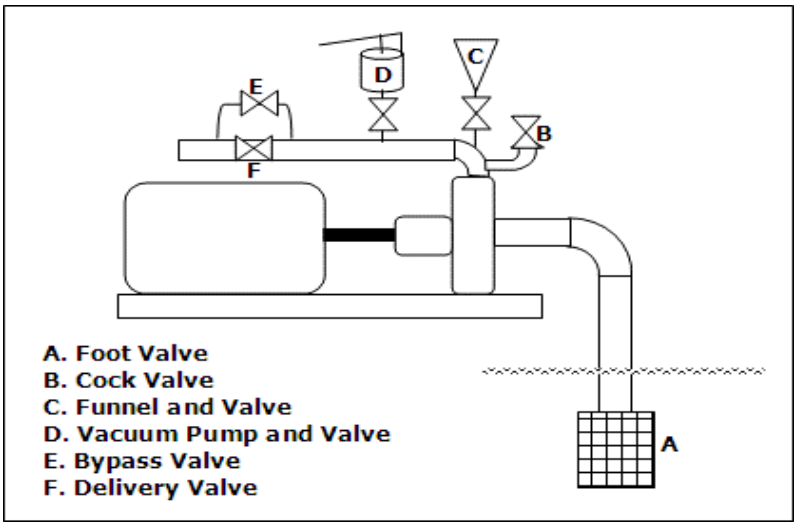


<u>Activity 8:</u> Techniques of priming a pump at the bottom of the dam wall (below the water level)

Steps

Step 1: Simply open the cock valve and keep it open until all the air has escaped and only water squirts out.

Step 2: Closed again the cock valve once, the pump is primed.



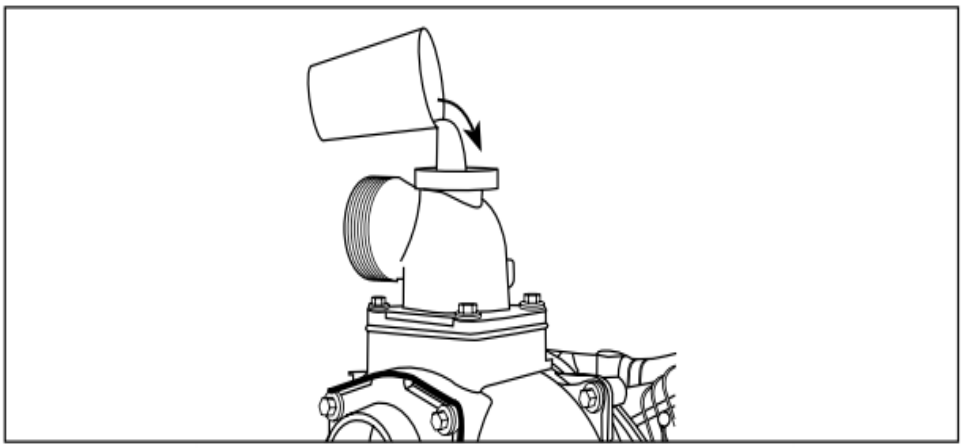
Activity 9: Techniques of priming a pump above the water level using the funnel

Steps

Step 1: Ensure that the delivery valve is closed

Step 2: Open the valve below the funnel;

Step 3: Pour clean, clear water into the funnel using a bucket. The water goes into the pump and the air will be expelled through the funnel;



Step 4: Continue to fill the pump until the funnel is brimming with water and no more air is expelled; the pump is now primed

Step 5: Close the valve below the funnel.

Activity 10: Techniques of priming a pump above the water level using vacuum pump

Steps

Step 1: Priming a pump above the water level using the vacuum pump:

Step 2: Ensure that the delivery valve and all other valves are closed;

Step 3: Open the valve below the vacuum pump;

Step 4: Use the handle of the vacuum pump to pump all the air out; the pump is now primed

Step 5: Close the valve below the vacuum pump

Activity 11: Techniques of checking whether the pump is primed or not

Steps

Step 1: open the cock valve on the delivery side of the pump.

Step 2: check whether the pump is full of water. If water squirts form the valve, the pump is primed, but if no water is present, the pump still has to be primed.

Activity 12: Techniques of lubricating pump bearings by greasing using greasing gun

Steps

Step 1: wear appropriate PPE

Step 1: Pull out the grease gun piston until it is fully retracted. The automatic clamping device will lock into place.

Step 2: Unscrew the top portion of the grease gun.

Step 3: Remove the cap/foil cover from the grease cartridge.

Step 4: Remove (cut with knife) or remove plastic cap of the opposite end of the cartridge.

Step 5: Insert the cartridge into the grease gun.

Step 6: Screw the top portion of the grease gun back on.

Step 7: Depress the automatic clamping device and press the piston into the gun.

Step 8: Push on the ventilation relief valve to allow for the escape of any entrapped air.

Step 9: Make sure grease is clean, free of grit and sand, and of the right type.

Step 10: Grease the bearing with a grease gun until the old grease is expelled from the casing.

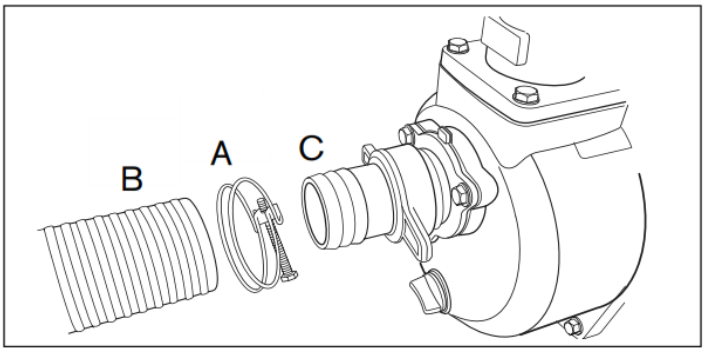
Step 11: Clean the nipple before greasing and wipe off the old grease with a rag.

Activity 13: techniques of connecting suction and discharge hose to pump

Steps

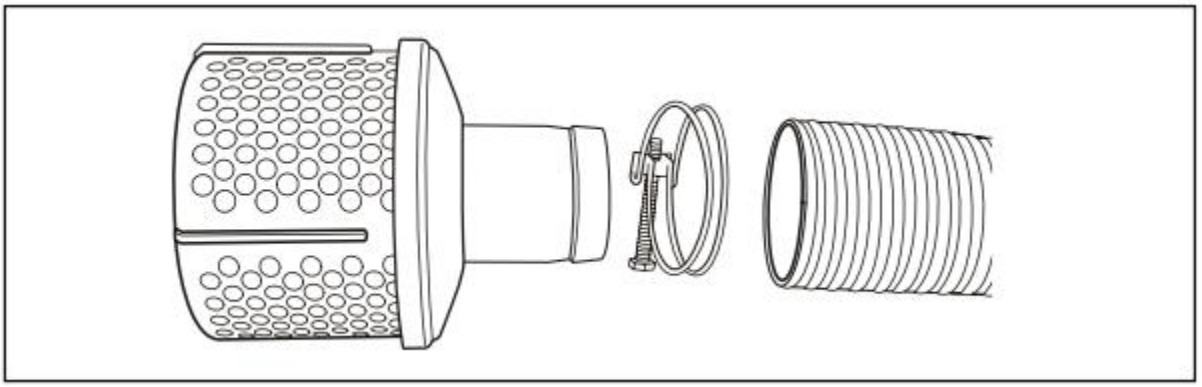
Step 1: Connecting suction hose to pump

Slide hose clamp (A) over end of hose (B). Slide suction hose onto hose barb (C). Tighten hose clamp securely to the hose.



Step 2: Attach suction hose to strainer basket

Slide hose clamp over hose. Attach open end of suction hose to strainer hose barb. Tighten hose clamp securely.

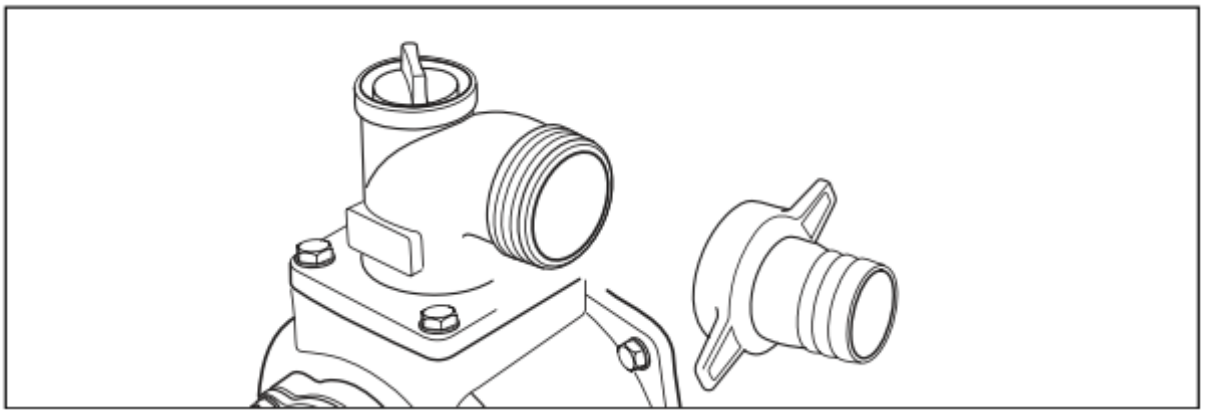


Step 3: Connect discharge hose (Optional)

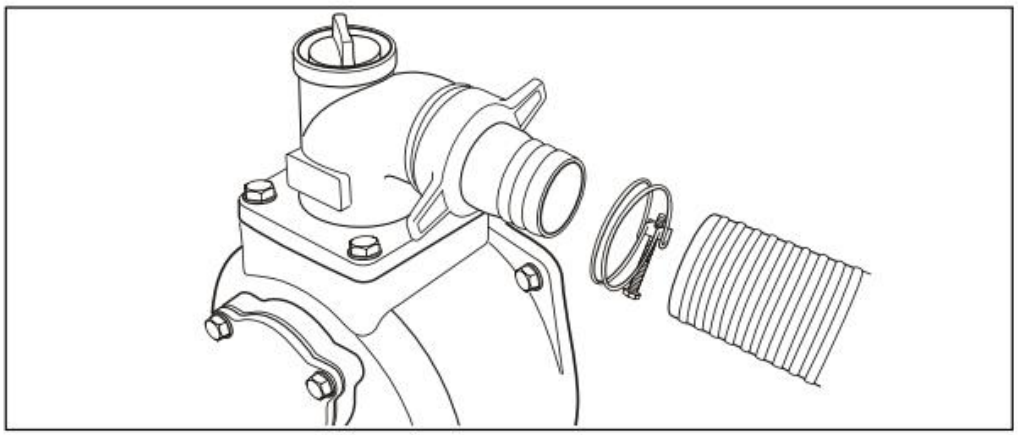
If desired, use a commercially available hose. DO NOT use a hose with an inside diameter smaller than the pump's discharge port size.

1. Slide barb cuff over hose barb. Insert rubber seal into end of barb cuff as shown earlier.

2. Screw hose barb assembly onto pump in clockwise rotation until hose barb assembly is tightened securely.



3. Slide hose clamp over end of discharge hose. Slide discharge hose onto hose barb. Tighten hose clamp securely.



4. You may choose to assemble the discharge and suction hose as shown above or by using camlock connections.

<u>Activity 14:</u> Techniques of performing general pre-start up inspection of pump stations

Steps

Step 1: Check water pump condition.

a. Inspect for signs of damage, oil or fuel leaks.

b. Remove excessive dirt and/or debris from the unit.

Step 2: Check suction and discharge hoses.

a. Inspect general condition of hoses to ensure hoses are in serviceable condition.

i. Suction hose must be reinforced construction to prevent hose collapse.

b. Ensure sealing washer in suction hose connecter is in operable condition.

c. Ensure hose connectors and clamps are securely installed.

d. Ensure filter is in operable condition and securely installed on suction hose.

Step 3: Check the engine.

a. Ensure proper engine oil amount.

b. Ensure air cleaner element is clean and installed.

c. Ensure proper fuel level amount.

Step 4:. Ensure water pump is on a level surface.

Step 5: Ensure engine switch is in the “OFF” position.

Step 6: Ensure water pump is at least 3ft (1m) away from building walls and other equipment during operation. Do NOT place flammable objects close to water pump.

Operation Sheet -2	**Operating pump stations**

<u>Activity 1:</u> Procedures for Starting the engine

Steps

Steps 1: Move the fuel cock to the “ON” position. The fuel valve handle will be vertical (pointing toward the ground).

Steps 2: To restart a warm engine, leave the choke level in the “OPEN” position.

Steps 3: Move the throttle valve lever away from the “LOWER” position, about 1/3 of the way toward the “UPPER” position.

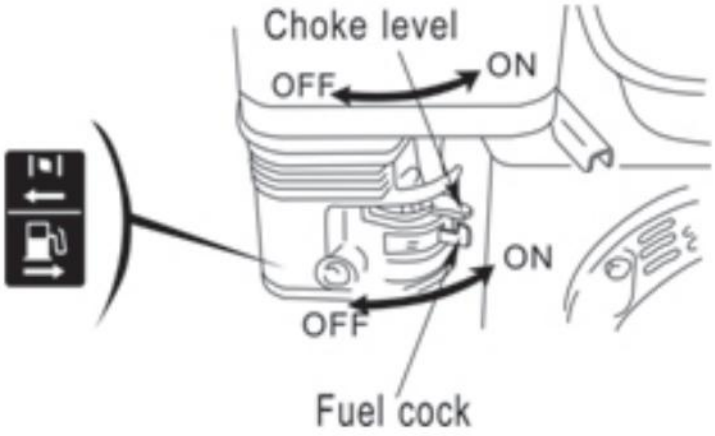
Steps 4: Turn the engine switch to the “ON” position.

IMPORTANT: If excessive fuel is present in the air/fuel mixture causing a “flooded” condition, move choke lever to “Run” position and pull handle repeatedly until engine starts.

Move choke lever to "Run" position a short distance at a time over several seconds in warm weather or minutes in cold weather. Let engine run smoothly before each change. Operate with choke in "Run" position.

IMPORTANT: It may take a few minutes for water pump to begin pumping water.

Steps 5: Pull the recoil starting handle lightly until resistance is felt, then pull briskly. Do NOT allow the starter handle to snap back against the engine. Return it gently to prevent damage to the starter.

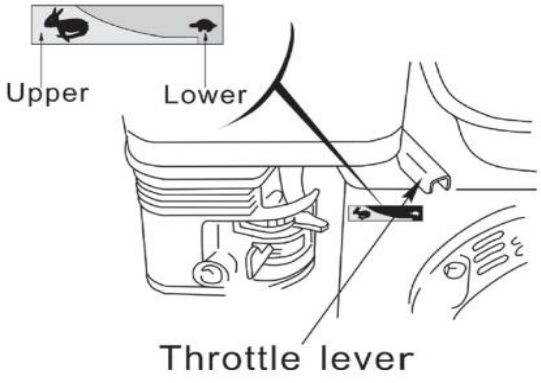


<u>Activity 2:</u> Procedures for setting the engine speed

Steps

Steps 1: After starting the engine, move the throttle valve lever to the "UPPER" position for self-priming, then check the pump output.

Steps 2: To adjust the pump output (which is controlled by the engine speed), move the throttle valve lever as needed to attain desired pump output. Moving the throttle valve in the "UPPER" direction will increase the pump output and moving the throttle valve in the "LOWER" direction will decrease pump output.



Activity 3: Procedures for stopping the engine

Steps

IN AN EMERGENCY:

Steps 1: Turn the engine switch to the “OFF” position.

NORMAL PROCEDURE:

Steps 1: Move the throttle valve lever to the “LOWER” position.

Steps 2: Turn the engine switch to the “OFF” position.

Steps 3: Turn the fuel cock to the “OFF” position.

Steps 4: Remove the water drain plug and drain the pump chamber.

Steps 5: Remove the water filler cap and flush the pump chamber with fresh, clean water.

Steps 6: Allow water to completely drain from the pump chamber.

Steps 7: Reinstall the water drain plug.

Steps 8: Reinstall the water filler cap.

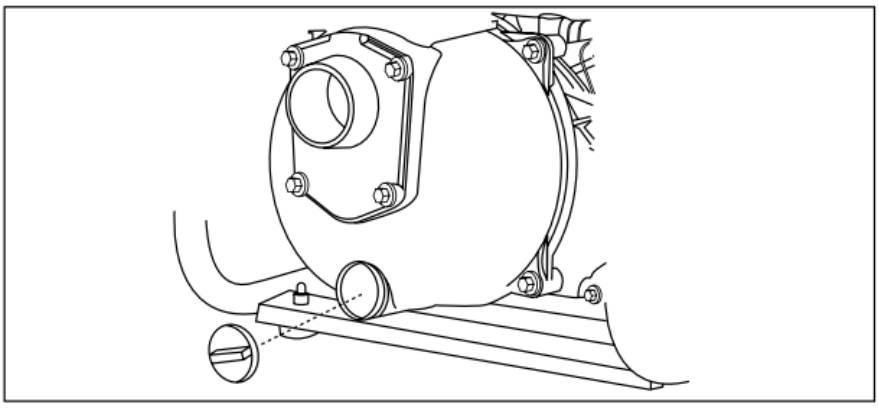
Activity 4: Procedures for draining and flushing water pump

Steps

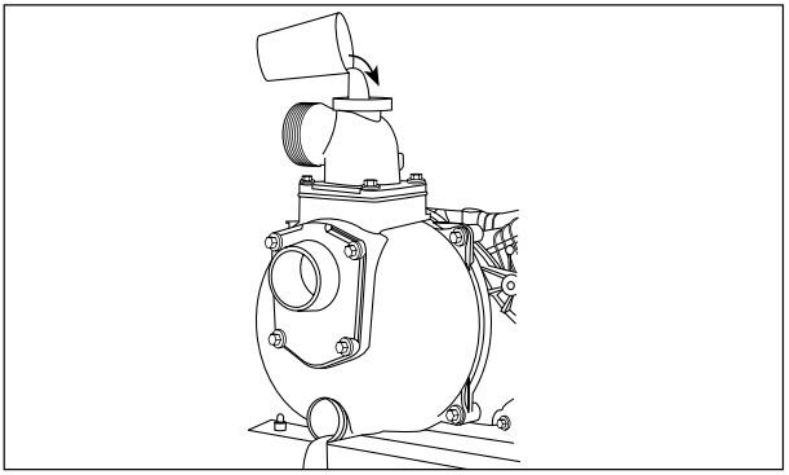
Steps 1: Disconnect and drain suction and discharge hoses.

Steps 2: Remove drain plug at bottom of pump.

Steps 3: Turn fuel valve to “Off” position



Steps 4: Remove primer plug from top of pump and flush internal components of pump with clean water.



Steps 4: Replace both plugs and finger tightens.

Activity 5: Procedures for adding fuel after operation pump

Steps

Steps 1: Turn water pump OFF and let it cool at least two (2) minutes before removing fuel cap. Loosen cap slowly to relieve pressure in tank.

Steps 2: Fill fuel tank outdoors.

- DO NOT overfill tank. Allow space for fuel expansion.
- If fuel spills, wait until it evaporates before starting engine.
- Keep fuel away from sparks, open flames, pilot lights, heat, and other ignition sources.

Steps 3: Clean area around fuel fill cap, remove cap.

Steps 4: Slowly add regular unleaded fuel to fuel tank. Be careful not to overfill. Fill to red indicator ring on the fuel filter, this will allow for fuel expansion

Steps 5: Install fuel cap and let any spilled fuel evaporate before starting engine.

Activity 6: Procedures for operating gate valve

Steps

Step 1: locate the valve

Step 2: gently turn the handle counter-clockwise (to the left) without applying excessive force – do not 'jerk' the handle.

Step 3: Set the valve to the desired pressure by turning it to a specific setting, or by measuring with a pressure meter downstream.

Step 4: increase the turn up to 6 turns this is the final position, a typical 1″ main control valve for a water line will take about six full turns to fully open.

Step 5: Stop turning as soon as there is any resistance.

Step 6: Gently turn the handle clockwise (to the write) without applying excessive force

Step 7: Stop turning as soon as there is any resistance. At this point the valve is closed.

Activity 7: procedure for operating Ball Valve

Steps

Step 1: locate the valve

Step 2: Fully open the valve by turning the handle/hand-wheel counter clock wise until you reach the mark (since they are made to work only in fully open or fully closed position and operation with partially open valves will damage the internal parts due to problems associated with erosion and turbulence of the flow.)

Step 3: Fully close the valve by turning the handle/hand-wheel clock wise direction until you reach the mark. (The handle/hand-wheel operation direction for the valve opening/closing is indicated direct on the component).

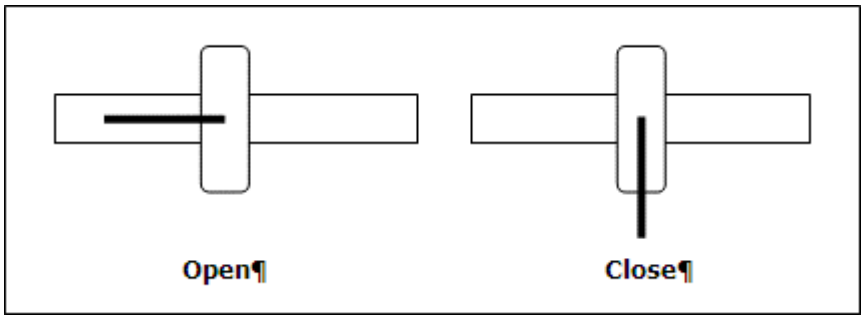
Activity 8: procedure for operating butterfly valve

Steps

Step 1: locate the valve

Step 2: To open the valve, turn the handle until it is in line with the pipe.

Step 3: To close the valve, turn the handle until it is perpendicular to the pipe



Operation Sheet -3	Operating centrifugal pump (electric motor driven)

Activity 1: procedure for centrifugal pump priming

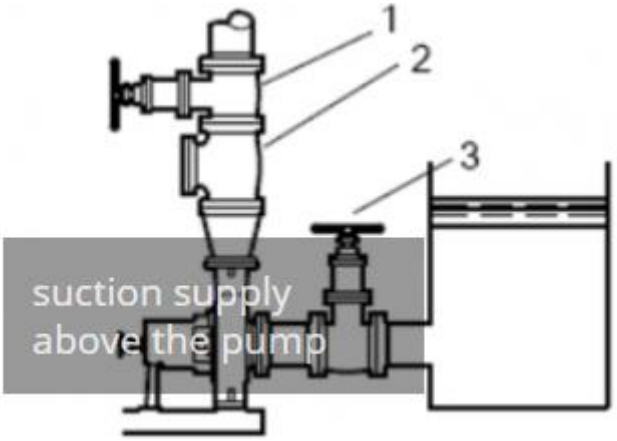
Condition 1: Prime the pump with the suction supply above the pump

Steps

Step 1: Slowly open the suction isolation valve.

Step 2: Open the air vents on the suction and discharge piping until the pumped fluid flows out.

Step 3: Close the air vents.



Suction supply above the pump

1. Discharge isolation valve
2. Check valve
3. Suction isolation valv

Condition 2: Prime the pump with the suction supply below the pump

Steps

Step 1: Close the discharge isolation valve.

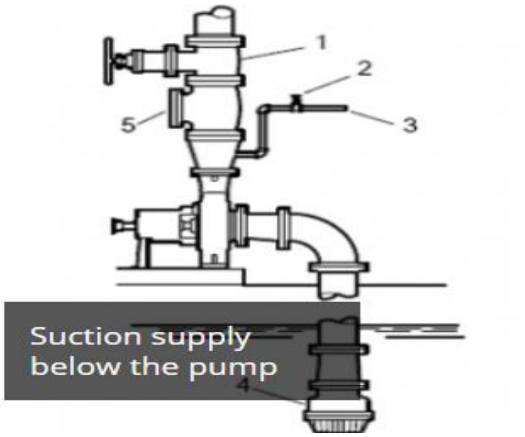
Step 2: Open the air vent valves in the casing.

Step 3: Open the valve in the outside supply line until only liquid escapes from the vent valves.

Step 4: Close the vent valves.

Step 5: Close the outside supply line.

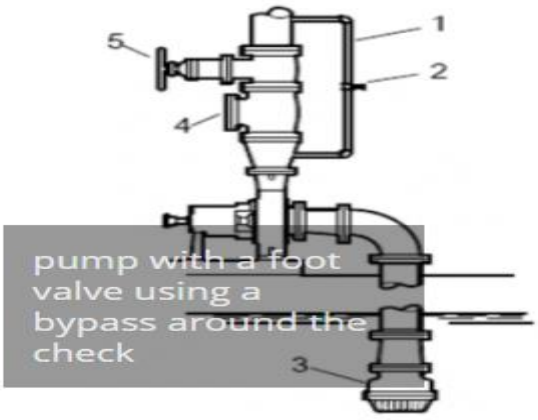
This illustration is an example of priming the pump with a foot valve and an outside supply:



Suction supply below the pump

1. Discharge isolation valve
2. Shutoff valve
3. From outside supply.
4. Foot valve
5. Check valve

This illustration is an example of priming the pump with a foot valve using a bypass around the check valve:



Pump with a foot valve using a bypass around the check

1. By-pass line
2. Shutoff valve
3. Foot valve
4. Check valve
5. Discharge isolation valve other

Activity 2: Pump Start-up Procedure

Steps

Step 1: Line up the pump valves.

Step 2: Ensure that the drain valve is closed.

Step 3: Open the suction valve.

Step 4: Open the vent valve to bleed off gases - when liquid comes from the vent valve - close it again. (This is called 'Priming the pump').

Step 5: Open the gland-seal valve (if fitted).

Step 6: Commission the bearing and oil cooling systems (if fitted).

Step 7: if an oil bottle or 'slinger-ring' reservoir is used for the bearings, ensure it is full and functioning properly.

Step 8: Check by hand that the pump shaft is freely rotating - (power is OFF at this point).

Step 9: Energize or, if the rule applies, have the electrician energize, the power supply.

Step 10: The discharge valve, at this point, should still be closed.

Step 11: Start the pump motor. Check that the pump is rotating in the correct direction.

Step 12: Check that the discharge pressure is steady - if not check at the vent and release any further trapped gas.

Step 13: Check for vibration, overheating and/or any undue noise from the pump, bearings or coupling.

Step 14: Re-check the lube and cooling systems and check for leaks at the pump glands. (With the 'packed' type gland seal, a slight leakage is desirable for lubrication and cooling of the gland). Open the discharge valve

Activity 3: Operate the centrifugal pump (standard operating procedure)

steps

Step 1: The suction valve of the pump to be opened which cause the fluid flow to the impeller and fill the volute of the centrifugal pump.

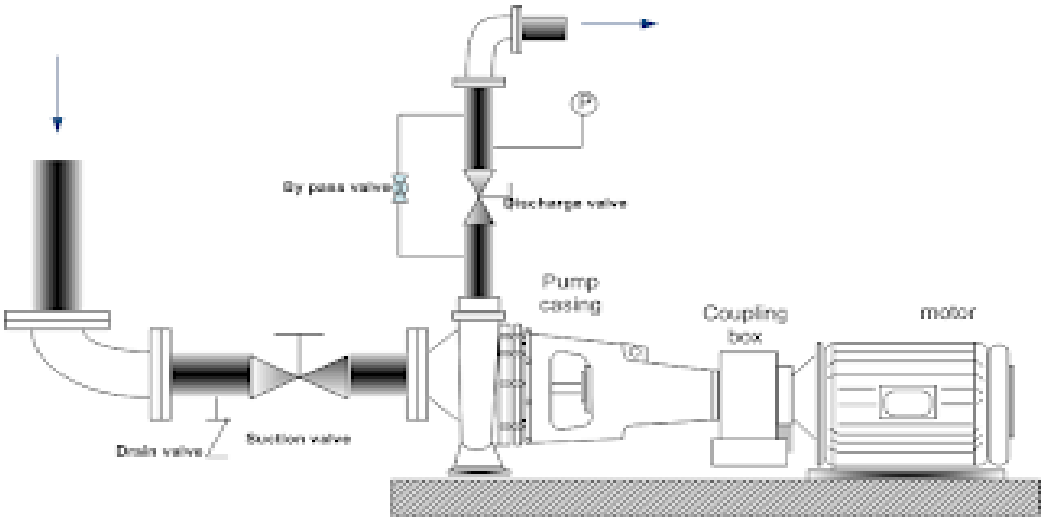
Step 2: Open the vent valve which is on the discharge line before the discharge valve of the centrifugal pump which causes all air to move out of the casing and filled with the pumping fluid only.

Step 3: When some quantity of the fluid comes out from the vent valve close the valve.

Step 4: Now open the bypass valve of the discharge valve which is near or side of the discharge valve on the discharge line.

Step 5: Now start the pump and let it attain its capacity in the pressure gauge on the discharge line.

Step 6: When the pressure gauge is stable it is time to open the discharge valve of the centrifugal pump.



Centrifugal pump system

<u>Activity 4:</u> stopping a pump of low and medium specific speed at normal Condition:

Steps

Step 1: Close the delivery valve gradually (sudden or fast closing should not be resorted to which can give rise to water hammer pressures).

Step 2: Switch off the motor.

Step 3: Open the air vent in case of V.T. and submersible pump.

Step 4: Stop lubricating oil or clear water supply in case of oil lubricated or clear water lubricated VT pump as applicable

LAP Test -1	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished:** _____

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks at irrigation pump station area within *40 hours.*

Task 1: Perform a pre-operational inspection (checks) of pump stations.

Task 2: Operate pump stations.

Task 3: Operate centrifugal pump. (electric motor driven)

Instruction Sheet	Learning Guide 53: Maintain pump stations

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Applying pump station maintenance standards.
- Inspecting pump station components according to organisational requirements, and identifying maintenance needs.
- Scheduling maintenance tasks and ordering appropriate materials.
- Conducting maintenance tasks according to organisational maintenance standards and manufacturer recommendations.
- Identifying and reporting pump station faults and carrying out minor repairs.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Apply pump station maintenance standards.
- Inspect pump station components according to organisational requirements, and identify maintenance needs.
- Schedule maintenance tasks and order appropriate materials.
- Conduct maintenance tasks according to organisational maintenance standards and manufacturer recommendations.
- Identify and report pump station faults and carry out minor repairs.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 5”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3,4 and 5 ” in each information sheets on pages 126, 130, 135, 138 and 141.

5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, 2 and3 on pages 143, 144, 145-151 and do the LAP Test on page 152”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Applying pump station maintenance standards

1.1 Introduction

Maintenance is a support function providing a cohesive process that assists operations and other departments in fulfilling the mission of the facility. This is achieved by ensuring that all equipment and systems are operated at an expected level of reliability within a specified budget and within the life cycle of the equipment.

Role of maintenance

The role of maintenance is to identify and remedy potential problems before they impact plant operation. This requires establishment of a set of operating parameters.

Maintenance, in the overall operation of a facility:

- Reduces the potential for unexpected equipment shutdown.
- Promotes a schedule of downtime that is most convenient.
- Assures the reliability of the system to maintain treatment standards.
- Reduces overall costs by correcting minor problems before they become major problems.
- Provides data on the usable service life of equipment and predicts a replacement schedule.

1.2 Lock-out procedures for mechanical and electrical components

The purpose of a lockout/tagout program is to ensure that all personnel follow standardized shutdown and start-up procedures to prevent accidental equipment start up, energization or release of stored energy and personal injury or property damage.

Lockout/tagout must be used to provide full protection for workers when performing maintenance or repair on equipment. If the energy isolating device for a piece of equipment is capable of being locked out then the energy control procedure should use a standardized lockout device similar to those shown in the figures below. A lockout device uses a positive means such as a lock, chain, blank flange, wedge, block or slip blind to prevent the energizing of a machine or equipment

Figure 70. Typical lockout device

A standardized tagout system must be used if an energy-isolating device is not capable of being locked out.

A **tagout device** is a prominent warning, such as a tag, which can be securely fastened to an energy-isolating device to indicate that the energy isolating device and equipment are not to be operated until the tag is removed. The tags should have appropriate warning language such as: *Do Not Start, Do Not Open, Do Not Close, Do Not Energize, and Do Not Operate.* The following two figures are examples of tagout devices

Figure 71. Warning tags

1.3 Pump station maintenance standards

Standard base system and process provide distinct benefit when compared to proprietary once, because standard envelops tried and true methods that user can incorporate for their own purpose these benefits includes interoperability across the systems, easier replication and reuse of system and best practice.

Maintenance standard incorporates proven methods to best perform task such as cleaning, lubrication, repair, component replacement data collection and more. These standards cover both maintenance procedures and system including emergency situations. They can also instruct operators how to create checklist of maintenance task. Overall, standard based system provides a safe path to successful maintenance practice of pump station equipments. Pump station maintenance standard for the operation and maintenance of irrigation and drainage pump station includes electrical maintenance standard, mechanical equipment maintenance standard and civil construction maintenance standard

- **Electrical maintenance standard**

  These standards include cleaning, lubrication, repair, component replacement data collection of electrical component of a pump such as electric motor. Even though, these type of maintenance standard is found in every organization which involved in irrigation and drainage pump station operation. The work should be outsourced and should be check that completed maintenance and repairs meet specifications
- **Mechanical equipment maintenance standard**

  These standards include cleaning, lubrication, repair, component replacement and data collection of mechanical component of a pump station such as pump, valves and flow meters.
- **Civil construction maintenance standard**

  These standards include cleaning, lubrication, repair, component replacement and data collection of structural component of a pump station such as valve chambers and meter pits.

Self-Check -1	Written Test

Direction I: Matching item (2 points each)

Instruction: Match column B with column A of the following questions and write your answer on the answer sheet provided in the next page:

A		B	
1.	Reduces the potential for unexpected equipment shutdown	**A.**	Lockout device
2.	Ensure that all personnel follow standardized shutdown and start-up procedures to prevent accidental equipment start up	**B.**	Repairing water meter
3.	Do Not Start, Do Not Open, Do Not Close	**C.**	Cleaning water meter pit
4.	Lock, chain, blank flange, wedge	**D.**	Maintenance
5.	Civil construction maintenance standard	**E.**	Repairing electric motor
6.	Electrical maintenance standard	**F.**	appropriate warning language of tags
7.	Mechanical equipment maintenance standard	**G.**	lockout/tagout

Note: **Satisfactory rating - 7 points and above** **Unsatisfactory - below 7 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Direction I: Matching questions

1. .....
2. ……
3. ……
4. ……
5. ……
6. .....
7. .....

Information Sheet-2	Inspecting pump station components and identifying maintenance needs

3.1 Preventive Maintenance

The heart of any maintenance operation is the preventive maintenance (PM) effort. PM involves regularly inspection or checking and servicing equipment so that it is in peak operating condition. Preventive maintenance allows the maintenance department to catch any potential problems before they impact the functioning of the equipment.

Preventive maintenance (PM) is sometimes referred to as “predictive” maintenance. This terminology reinforces the idea that PM is planned and scheduled. We can “predict” when it will be done, what will be done, and how much it will cost in terms of birr, time, equipment, and personnel. Advanced maintenance techniques, such as vibration analysis and lubrication analysis, may provide clues to help determine when maintenance is required.

Some advantages of PM are:

- It is predictable, making budgeting, planning, and resource leveling possible.
- When properly practiced, it generally prevents most major problems, thus reducing forced outages, “reactive maintenance,” and maintenance costs in general.
- It assures managers that equipment is being maintained.
- It is easily understood and justified.

PM does have some drawbacks:

- It is time consuming and resource intensive.
- It does not consider actual equipment condition when scheduling or performing the maintenance.
- It can cause problems in equipment in addition to solving them (e.g., damaging seals, stripping threads).

2.1 Inspecting pump station components

To identify maintenance needed for pump station components the first procedure is inspecting the station and look for any problem. Operator’s rounds are the most frequent preventive maintenance activity

2.2 Identify maintenance needs for pumps and pump stations

After Inspecting pump station components thoroughly the inspection result will decide the problem and the possible cause the respective maintenance need. The following troubleshooting guide can be used

PROBLEM	CAUSE	CORRECTION
Pump will not pump.	1. Air leak in suction hose. 2. The suction and/or discharge line(s) may be blocked. 3. The end of the suction line is not submerged. 4. Total head is too high for this pump to work against	1. Make sure suction hose is double clamped at joints, clamps are tight, fittings have thread compound and are tight, with no nicks or cuts in hose. 2. Check to see that the hoses and filter are in good working order. 3. Increase its length, or move pump closer to source of liquid. 4. Reduce total head or use a higher head pump.
Pump will not prime.	1. Excessive suction lift (*1).	1. Move the pump closer to liquid source.
Priming takes a long time.	1. Suction line is quite long. 2. Air pockets or leaks in the suction line.	1. Move pump closer to source. 2. Check the line for loose connections. Make sure suction hose is submerged.
Pump does not perform as well as it should.	1. Flow is restricted due to debris build-up. 2. Insufficient submergence of the end of suction hose. 3. Excessively worn impeller (*2). 4. Seal is damaged (*3). Liquid will be leaking through the middle of the adapter. 5. Air pockets or leaks in the suction hose. 6. Clogged impeller. 7. Engine throttle is in SLOW position.	1. Clean the hoses, fittings and filter. 2. The end of the suction line must be submerged. 3. Replace impeller. 4. Replace the seal. 5. Check suction hose. 6. Remove casing to clean out. 7. Move throttle to FAST position.
Pump loses prime.	1. Water level drops below the end of the suction line.	1. Increase length of suction line or move the pump closer to the water source.
Pump will not start.	1. No fuel. 2. Faulty spark plug. 3. Fuel valve lever is in the OFF position. 4. Ignition switch is in the OFF position. 5. Choke is in the wrong position.	1. Allow engine to cool for 2 minutes, then fill fuel tank. 2. Replace spark plug. 3. Turn the fuel valve lever to the ON position. 4. Turn the ignition switch to the ON position. 5. Slide choke lever to the CHOKE position.
Pump starts, but runs roughly.	1. Choke is in the wrong position. 2. Spark plug wire is loose. 3. Faulty spark plug. 4. Fuel is contaminated (water, debris, etc.).	1. Slide choke lever to the RUN position. 2. Attach wire to spark plug securely. 3. Replace spark plug. 4. Allow engine to cool for 2 minutes, then drain fuel tank and carburetor. Fill tank with fresh fuel.
Pump shuts down during operation.	1. No fuel. 2. Low oil sensor shuts down unit.	1. Allow engine to cool for 2 minutes, then fill fuel tank. 2. Make sure unit is on flat surface. Check oil level and add more if necessary.

Table 3. troubleshooting pumps

Self-Check -2	Written Test

Direction I: Short answer (26 points)

Instruction: Give short answer for the following questions and write your answer sheet provided in the next page:

1. Write the advantage and disadvantage of preventive maintenance?(6 points)
2. What are the possible causes for the following pump problem? (20 points)

    A. Pump will not start

    B. pump will not prime

    C. Pump will not pump

    D. priming takes a lot of time

    E. Pump shut down during operation

Note: **Satisfactory rating - 13 points and above** **Unsatisfactory - below 13 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-2

Score = _____
Rating: _____

Name: _____ **Date:** _____

Direction I: Short answer questions

1. ……
   ……
   ……
   ……

2.

A.	
B.	
C.	
D.	
E.	

Information Sheet-3	Scheduling maintenance tasks and ordering appropriate materials

3.1 Maintenance schedule

A maintenance program is comprised of many activities. In essence, these activities can be grouped into types of maintenance: **preventive maintenance; corrective maintenance; and breakdown maintenance**.

Preventive Maintenance

The idea of preventive maintenance (PM) is to avoid the need for costly repairs due to lack of attention to a system. It is performed on a regular basis and is scheduled in advance.

Corrective Maintenance

Corrective maintenance (CM) has the goal of preventing further damage to equipment that has suffered some ill effect. The maintenance is a result of inspecting the equipment and it addresses a specific problem. Often, a short time period exists between identification of the problem and the need to correct it.

A quick corrective maintenance can prevent major system failure and prevents the equipment from being removed from service for extended periods without advanced warning

Breakdown Maintenance

Breakdown maintenance is often a result of the failure of PM or CM functions. It is an unscheduled task and is often time-sensitive. The equipment usually must be removed from service for a prolonged period; spare parts may not be on hand; and the cost in labor is extensive.

Frequency

Maintenance tasks are performed with varying degrees of frequency. The frequency may depend upon manufacturers' recommendations, amount of wear and tear received, staff time constraints, or plant conditions.

List some maintenance activities that occur at your plant during these time frames:

- **Daily**
- **Weekly**
- **Monthly**
- **Quarterly**
- **Annually**

(Remember that this does not mean September 1. Annual maintenance is performed one year from the last incident of maintenance. This staggers task for personnel requirements, and meets requirements for equipment. Use the date of installation to determine the annual maintenance date.)

- **Seasonally**

Scheduled Repairs

Scheduled repairs allow management to plan staffing, parts, and financial needs. There are three types of scheduled repairs in the facility.

- Time-Planned Repairs are scheduled on a calendar basis. They are done every day, every month, every year, and so forth.
- Running Repairs and Emergencies are activities that have not been scheduled, but must be completed in a specified period of time. These types of repairs upset normal organized operations at the plant.
- Process Adjustments are completed as needed. Some equipment allows adjustment only while in operation. Some equipment requires regular adjustment, as normal usage upsets its normal operating parameters or calibrations.

Below is an example of a fairly comprehensive maintenance plan, which also includes essential monitoring actions:

Frequency	*Item*	*Task and Action*
Daily	Pressures	Check that pump and block pressures are within prescribed limits.
	Emitter operation	Check for clogged, broken or misplaced emitters. Repair, replace, unclog or reposition emitters.
	Leaks	Check for water wastage and leaks in pipes and other equipment and repair immediately.
	Primary filter	Flush primary filters as prescribed.
	Fertigation application	Check that fertigation applications are within specifications.
Weekly	Lateral lines	Flush lateral lines as prescribed.
	Exposed joints	Check and repair if needed, e.g. quick coupling rubbers
	Secondary filters	Flush secondary filters as prescribed
	System pressure and flow	Check that system pressure and flow are as per irrigation design plan.
	Pump operation	Check that pump operation is within prescribed parameters.
	Block pressures for automated valves	Check that block pressures are as prescribed where automated valves are used.
	Pump oil levels	Check pump oil levels as prescribed.
	Fertigation plant	Inspect fertigation plant.
	Pipes (above and below ground)	Check for leaks and repair
Monthly	Valves, water meters, and gauges	Visually check valves, water meters and gauges and look for damage and / or vandalism.
	Filters	Open and inspect filters as prescribed.
	Pump pipe work	Check for leaks at pump station that causes water losses and air locks.
	Pump motor	Pump motor must be greased as prescribed.
Annually	Valves	Service valves and physically check correct operation.
	Filters	Clean filters thoroughly and replace sand in sand filters annually or biennially.
	Pump	Change oil in pump.
	Water sampling	Take a water sample at the end of lateral lines and send it in for analysis.
	Emitter delivery tests	Test specific emitters for discharge and pressure.
	Sprinkler parts	Replace nozzles annually and other parts when needed.
2-10 years	Pump	Replace bearings and other wearing parts on pump and motor every five years.
	Hydraulic valves	Replace diaphragms on hydraulic valves every three years.
	Poly pipe and emitters	Replace poly pipe and emitters every seven to ten years.

Table 4. schedule maintenance of pump stations

Self-Check -3	Written Test

Direction I: Matching item (2 points each)

Instruction: Match column B with column A of the following questions and write your answer on the answer sheet provided in the next page:

A		B	
1.	avoid the need for costly repairs due to lack of attention to a system	**A.**	Running Repairs and Emergencies
2.	Change oil in pump	**B.**	Frequency of maintenance activity
3.	scheduled on a calendar basis	**C.**	Monthly schedule
4.	has the goal of preventing further damage to equipment that has suffered some ill effect	**D.**	Preventive maintenance
5.	depend upon manufacturers' recommendations, amount of wear and tear	**E.**	Daily maintenance schedule
6.	are activities that have not been scheduled, but must be completed in a specified period of time	**F.**	Corrective maintenance
7.	Leakage	**G.**	Time-Planned Repairs
8	Pump oil level	**H.**	Annual maintenance schedule
9	Pump motor must be greased	**I.**	2-10 years maintenance schedule
10	Bearing replacement	**J.**	Weekly schedule

Note: **Satisfactory rating - 10 points and above** **Unsatisfactory - below 10 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-3

Score = _____

Rating: _____

Name: _____ Date: _____

Direction I: Matching questions

1. .....
2. ……
3. ……
4. ……
5. ……
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7. .....
8. ……
9. ……
10. ……

Information Sheet-4	Conducting maintenance tasks

4.1 Conducting pump station maintenance

The proper maintenance and upkeep of pumping stations is essential to guaranteeing long term reliability. Pump station maintenance should be done according to organizational maintenance standards and manufacturer recommendations. After the problem is identified and the respective maintenance type is recommended the next step will be the application of pump station maintenance.

Common pumping system problems

Poor design and improper system operation can create problems in both pumps and pumping systems. As rotating equipment, pumps are subject to wear, erosion, cavitation, and leakage. Many pumping system problems can result from improper pump selection and operation and lack of routine maintenance. If they are not selected or operated properly, pumps can require considerable maintenance.

What are the benefits of having pump maintenance?

- Reduced running costs including energy and maintenance
- Greater life expectancy for pumping equipment
- Reduced risk of breakdown with its resultant
- Better plant utilization and return on capital
- Improved environmental conditions

Refer the following you tube video links for repair and maintenance of centrifugal pump

1. https://www.youtube.com/watch?v=csqPXsR82L4
2. https://www.youtube.com/watch?v=hdZUsV1pFs8
3. https://www.youtube.com/watch?v=g6WSysv9zfY

Self-Check -4	Written Test

Direction I: Short answer (10 points)

Instruction: Give short answer for the following questions and write your answer sheet provided in the next page:

1. Write the benefits of pump station maintenance? (6 points)
2. The proper maintenance and upkeep of pumping stations is essential to guaranteeing long term reliability. Explain how? (4 points)

Note: **Satisfactory rating - 13 points and above** **Unsatisfactory - below 13 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-4

Score = _____

Rating: _____

Name: _____ **Date:** _____

Direction I: Short answer questions

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2. .....
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Information Sheet-5	Identifying and reporting pump station faults and carrying out minor repairs

5.1 Identifying and reporting pump station faults

Pump station faulty beyond the scope the operator should be reported to the supervisor. These faults include the fallowing

- Flow fluctuations outside acceptable limits
- Over-heating bearing
- Blocked suction lines
- Vibrating drive shaft
- Broken impellers
- Electric motor failure

Reporting on data

The accuracy and integrity of data should be maintained. This means that data should be correct and updated at the prescribed and scheduled dates and in some cases specific time of day. Should the data not be collected and recorded correctly, the integrity of the data is corrupted. Data should be reported on by using required reporting formats. This should be available at the farm.

Self-Check -5	Written Test

Direction I: Short answer (10 points)

Instruction: Give short answer for the following questions and write your answer sheet provided in the next page:

1. List down some of Pump station faulty beyond the scope the operator should be reported to the supervisor?(6 points)

2. The accuracy and integrity of data should be maintained. Explain how? (2 points)

Note: **Satisfactory rating - 4 points and above** **Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-5

Score = _____

Rating: _____

Name: _____ **Date:** _____

Direction I: Short answer questions

1. ……
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2. ……
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   ……

Operation Sheet 1	Securing ball valve on supply pipeline

Techniques of securing ball valve on supply pipeline

Steps

Step 1: Notify that a lockout or tagout system is going to be used

Step 2: Require color code ball vale lock-out device and padlock as shown below

Step 3: Get lock-out tag

Figure 3.2. Tags

Step 4: lock the valves using padlock

Operation Sheet 2	Inspecting pump station components

Activity 1: Techniques of performing routine inspections

Steps

Step 1: Check the level and condition of the oil

Step 2: Check for unusual noise, vibration, and bearing temperatures.

Step 3: Check the pump and piping for leaks.

Step 4: Inspect the seal

Step 5: Inspect suction and discharge flanges for any leak.

Step 6: Inspect pump casing for any unusual damage signs.

Step 7: Inspect the discharge pressure.

Step 8: Inspect the temperature.

Step 9: Check the seal chamber and stuffing box for leaks.

Step 10: Ensure that there are no leaks from the mechanical seal.

Activity 2: Techniques of performing three month inspections

Steps

Step 1: Check that the foundation and the hold-down bolts are tight.

Step 2: Check the mechanical seal if the pump has been left idle, and replace as required.

Step 3: Change the oil every three months (2000 operating hours) at minimum.

Step 4: Change the oil more often if there are adverse atmospheric or other conditions that might contaminate or break down the oil.

Step 5: Check the shaft alignment, and realign as required.

Activity 3: Techniques of performing annual inspections

Steps

Step 1: Check the pump capacity.

Step 2: Check the pump pressure.

Step 3: Check the pump power.

Operation Sheet 3	Performing pump station maintenance

<u>Activity 1:</u> Techniques of performing daily preventive maintenance of pumps

Steps

Step 1: Check pump for noisy bearings and cavitations

Step 2: Check bearing oil for water and discoloration

Step 3: Feel all bearings for temperature

Step 4: Inspect bearings and oil rings through filling ports. Wipe bearing covers clean.

Step 5: Check oil leaks at the gaskets

Step 6: Determine if the mechanical seal conditions are normal

Step 7: Determine if steam leakage at packing and glands is normal

Step 8: Check for leaks at pressure casing and gaskets

<u>Activity 2:</u> Techniques of performing monthly/quarterly maintenance of pumps

Steps

Step 1: Clean the pump, motor and other accessories.

Step 2: Check coupling bushes/rubber spider.

Step 3: Check stuffing box, gland etc.

Step 4: Records of pressure, voltage and current.

Step 5: Check and repair of leakage from mechanical seal.

Step 6: Check and repair in case of sparks in motor.

Step 7: Check for free movement of the gland of the stuffing box.

Step 8: Check gland packing and replace if necessary.

Step 9: Clean and apply oil to the gland bolts.

Step 10: Inspect the mechanical seal for wear and replacement, if necessary.

Step 11: Check condition of bearing oil and replace or top up, if necessary.

<u>Activity 3:</u> Techniques of performing six months maintenance of pumps

Steps

Step 1: Verify and rectify alignment of pump and drive.

Step 2: Clean oil lubricated bearings and replenish with fresh oil.

Step 3: Tighten the foundation bolts and holding down bolts of pump and motor mounting on base plate or frame.

Step 4: Check vibration level with instruments if available; otherwise by observation.

Step 5: Clean flow indicator, other instruments and appurtenances in the pump house.

Activity 4: Techniques of performing six yearly maintenance of pumps

Steps

Step 1: Clean and flush bearings with kerosene and examine for flaws developed like corrosion, wear and scratches.

Step 2: Immediately after cleaning, the bearings should be coated with oil or grease to prevent ingress of dirt or moisture.

Step 3: Clean bearing housing and examine for flaws like wearing, grooving etc. Change oil or grease in bearing housing.

Step 4: Examine shaft sleeves for wear or scour and necessary rectification. If shaft sleeves are not used, shaft at gland packing's should be examined for wear.

Step 5: Check stuffing box, glands, lantern ring, and mechanical seal and rectify if necessary.

Step 6: Check clearances in wearing ring.

Step 7: Check impeller hubs and vane tips for any pitting or erosion.

Step 8: Check interior of volute, casing and diffuser for pitting, erosion, and rough surface.

Step 9: All vital instruments i.e. pressure gauge, vacuum gauge, ammeter, voltmeter, watt meters, frequency meter, tachometer, flow meter etc. should be calibrated.

Step 10: Conduct performance test of the pump for discharge, head and efficiency.

Activity 5: Techniques of performing monthly/quarterly maintenance of motors

Steps

Step 1: Clean external surface of motor.

Step 2: Examine earth connections and motor leads.

Step 3: Check temperature of motor and check whether overheated.

Step 4: Lubricate bearings.

Step 5: Verify and rectify any abnormal noise in bearings.

Step 6: Clean belt tension and reduce it where there is excessive tension.

Step 7: Blow dust from the motor.

Activity 6: Techniques of performing six month maintenance of motors

Steps

Step 1: Clean oil lubricated bearings and replenish fresh oil.

Step 2: Wipe brush holders and check contact faces of brushes of slip-ring motors.

Step 3: Check insulation resistance of the motor, tightness of cable gland, lug and connecting bolts.

Step 4: Check and tighten foundation bolts and bolts holding motor and frame.

Step 5: Check vibration level with instrument if available.

Step 6: Clean winding of motor, if necessary.

Activity 7: Techniques of performing yearly maintenance of motors

Steps

Step 1: Clean and flush bearings with kerosene and examine for flaws developed, wear and scratches. Cleaned bearings should be coated with oil or grease.

Step 2: Change oil or grease in bearing housing.

Step 3: Blow out dust from windings of motors thoroughly with clean dry air.

Step 4: Clean and varnish dirty and oily windings.

Step 5: Check condition of starter, stamping, insulation, terminal box, fan etc.

Step 6: Check insulation resistance to earth and between phases of motors windings, control gear and wiring.

Step 7: Check air gaps.

Activity 8: Techniques of performing valve maintenance

I. Foot Valve

Steps

Step 1: Clean foot valve once in three months.

Step 2: Clean flap of the foot valve once in two months to ensure leak proof operation.

Step 3: Inspect the valve thoroughly once in a year. Check for leakage through foot valve after priming.

Step 4: Check gland packing once in a month and grease it as per need and change the packing if needed. It should be ensured.

Step 5: Apply grease to reduction gears thrust bearing once in three months.

Step 6: Check tight closure of the valve once in three months.

Step 7: Operate valve once a quarter to full travel.

Step 8: Inspect the valve thoroughly for flaws in guide channel, guide lugs, spindle, spindle nut, stuffing box etc. once in a year.

II. Reflux (non-return) valve

Steps

Step 1: Check proper operation of hinged door and tight closure under no-flow condition once in 3 months.

Step 2: The valve shall be thoroughly inspected annually.

Step 3: Condition of dampening arrangement should be thoroughly examined once in year and necessary maintenance and rectification should be carried out as per manufacturer's instruction.

Step 4: In case of dampening arrangement, check for oil leakage and replace oil once in a year.

III. Butterfly valve

Steps

Step 1: Check seal ring and tight shut-off once in three months.

Step 2: Lubricate gearing arrangement and bearing once in three months.

Step 3: Inspect the valve thoroughly including complete operations once in a year.

Step 4: Change oil or grease in gearing arrangement once in a year.

Activity 9: Techniques of performing Poly-ethylene pipes maintenance

Steps

Step 1: wear appropriate PPE

Step 2: Check for damage on pipes.

Step 3: Repair or replace pipe line.

Activity 10: Techniques of performing permanent installed underground pipelines maintenance

Steps

Step 1: Fill the lines very slowly, allowing air to escape and prevent bursting of pipes.

Step 2: Check for visible signs of sub-surface leaks.

Step 3: Flush and scour the pipes a few times each year.

Activity 11: Techniques of performing hose filter and hoses maintenance

Steps

Step 1: Examine the filter on the suction hose.

Step 2: Clean it if the slots are clogged or replace it if filter is damaged.

Step 3: Inspect the hoses each time before using them.

Step 4: Check for cuts, leaks, abrasions or bulging, damage or movement of couplings. If any of these conditions exist, replace the hose.

Activity 12: Techniques of changing engine oil

Steps

Steps 1: Make sure water pump is on a flat, level surface.

Steps 2: Disconnect the spark plug wire from the spark plug and place the wire where it cannot contact spark plug.

Steps 3: Clean area around oil drain plug. The oil drain plug is located at base of engine.

Steps 4: Remove oil fill cap

Steps 5: Remove oil drain plug and drain oil completely into a suitable container.

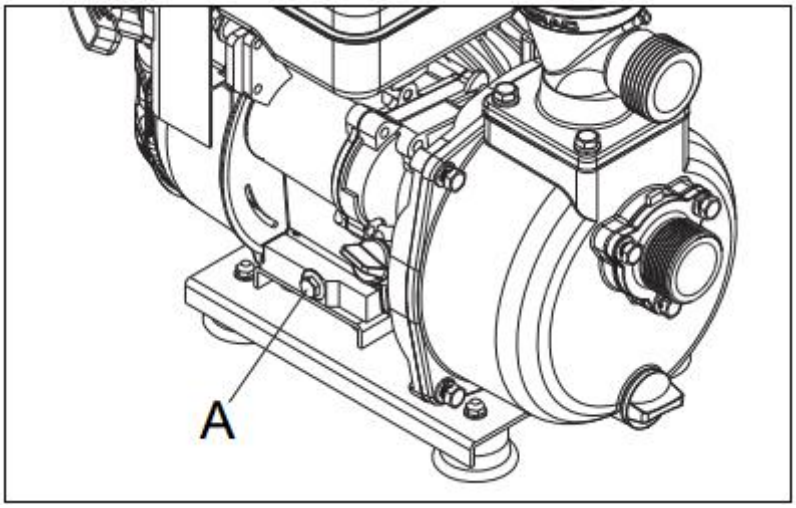
Steps 6: Reinstall oil drain plug and tighten securely.

Steps 7: Slowly pour oil into oil fill opening to the proper level on the dipstick. DO NOT overfill.

Steps 8: Reinstall oil fill cap. Finger tighten cap securely.

Steps 9: Wipe up any spilled oil.

Steps 10: Properly dispose of oil in an accordance with all local regulations



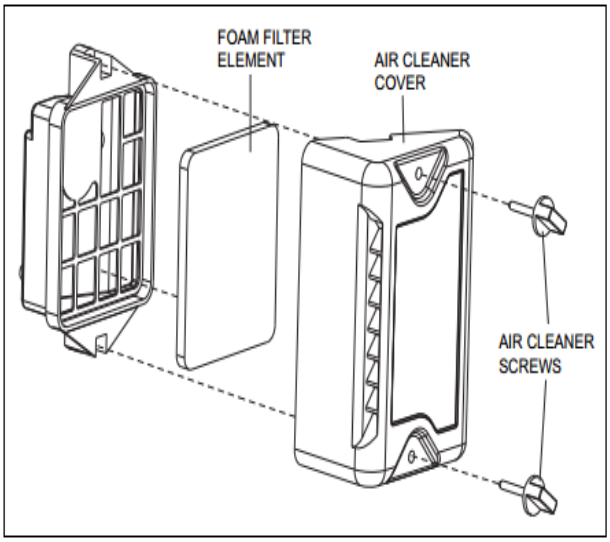
Activity 13: Techniques of servicing air cleaner

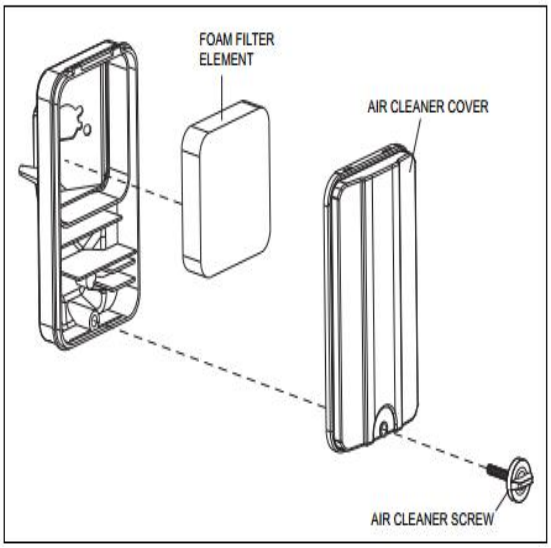
Steps

Steps 1: Remove air cleaner screw(s), and pull off the air cleaner cover

Steps 2: Remove old foam filter and replace with a clean new foam filter.

Steps 3: Install cover and insert air cleaner screw(s).





Activity 14: Techniques of servicing spark plug

Steps

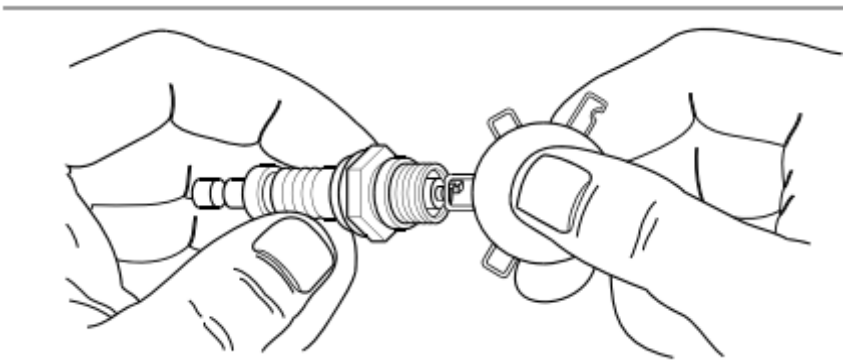
Steps 1: Clean area around spark plug.

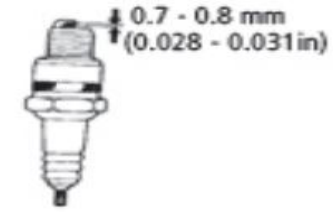
Steps 2: Remove and inspect spark plug.

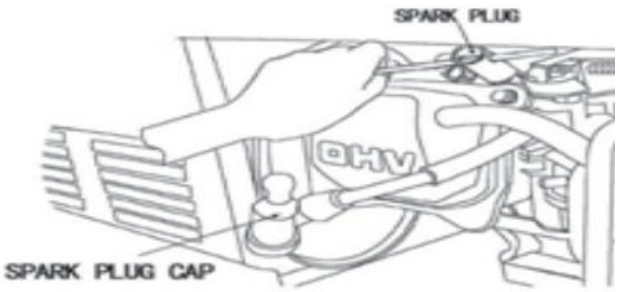
Steps 3: Check electrode gap with wire feeler gauge and reset spark plug gap to recommended gap if necessary.

Steps 4: Replace spark plug if electrodes are pitted, burned or porcelain is cracked. Use the recommended replacement plug. See Specifications.

Steps 5: Install spark plug and tighten firmly







SPARK PLUG REMOVAL

Activity 15: Techniques of fuel system maintenance

Steps

Steps 1: wear appropriate PPE

Steps 2: Turn the fuel cock (valve) to the “OFF” Position.

Steps 3: Remove the carburetor bowl by removing the mounting bolt located at the bottom of the bowl.

Steps 4: Dump out the old fuel and sediment into an approved container.

Steps 5: Clean carburetor bowl thoroughly.

Steps 6: Fit a new rubber washer into place and re-attach fuel bowl to the carburetor.

Steps 7: After bowl is securely back in place, turn the fuel cock (valve) to the "ON" position for use.

Steps 8: Units equipped with a pre-filter for fuel will have a filter housed just below the fuel cock. Remove the fuel filter element (refer to "Fuel Filter Element Removal") and clean or replace

(See diagram below) and either clean or replace the fuel filter element. Re-assemble the fuel filter element (refer to "Fuel Filter Element Assembly" diagram below).

FUEL FILTER
ELEMENT REMOVAL

FUEL FILTER
ELEMENT ASSEMBLY

LAP Test -1	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished:** _____

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks at irrigation pump station area within *80 hours.*

Task 1: Secure ball valve on supply line

Task 2: Inspect pump station components

Task 3: Perform pump station maintenance

Instruction Sheet	Learning Guide 54: monitor and adjust pump station performance

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Applying pump station performance targets.
- Identifying and applying monitoring points and timing.
- Monitoring pump station and making adjustments, where necessary, to maintain operational parameters.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Apply pump station performance targets.
- Identify and apply monitoring points and timing.
- Monitor pump station and making adjustments, where necessary, to maintain operational parameters.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 3”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2, and 3 ” in each information sheets on pages 156, 159 and 164.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1 and 2 on pages 166 and 167 do the LAP Test on page 168”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Applying pump station performance targets

1.1 Understanding pump station performance targets

Effective irrigation water management begins with accurate water measurement. Water measurement is required to determine both total volumes of water and flow rates pumped. Measurement of volumes will verify that the proper amount of water is applied at each irrigation and that amounts permitted by water management districts are not exceeded. Flow rate measurements help to ensure that the irrigation system is operating properly. For example, lower than normal flow rates may indicate the need for pump repair or adjustment, partially closed or obstructed valves or pipelines, or clogged drip emitters. Higher than normal flow rates may indicate broken pipelines, defective flush valves, too many zones operating simultaneously.

Performance parameters – centrifugal pump

- pump curve
- acceptable operating range
- net positive suction head - NPSH
- net positive discharge head - NPDH
- pressure gauges – actual NPSH & NPDH conditions
- flow meter – gpm

Head/Capacity Curves

Any centrifugal pump will deliver a range of flows. As the flow rate increases, the amount of head that the pump can produce decreases. Pump efficiency also varies with the flow rate. A plot of pump head (on the y-axis) for different flow rates (on the x-axis) is the Head/Capacity curve.

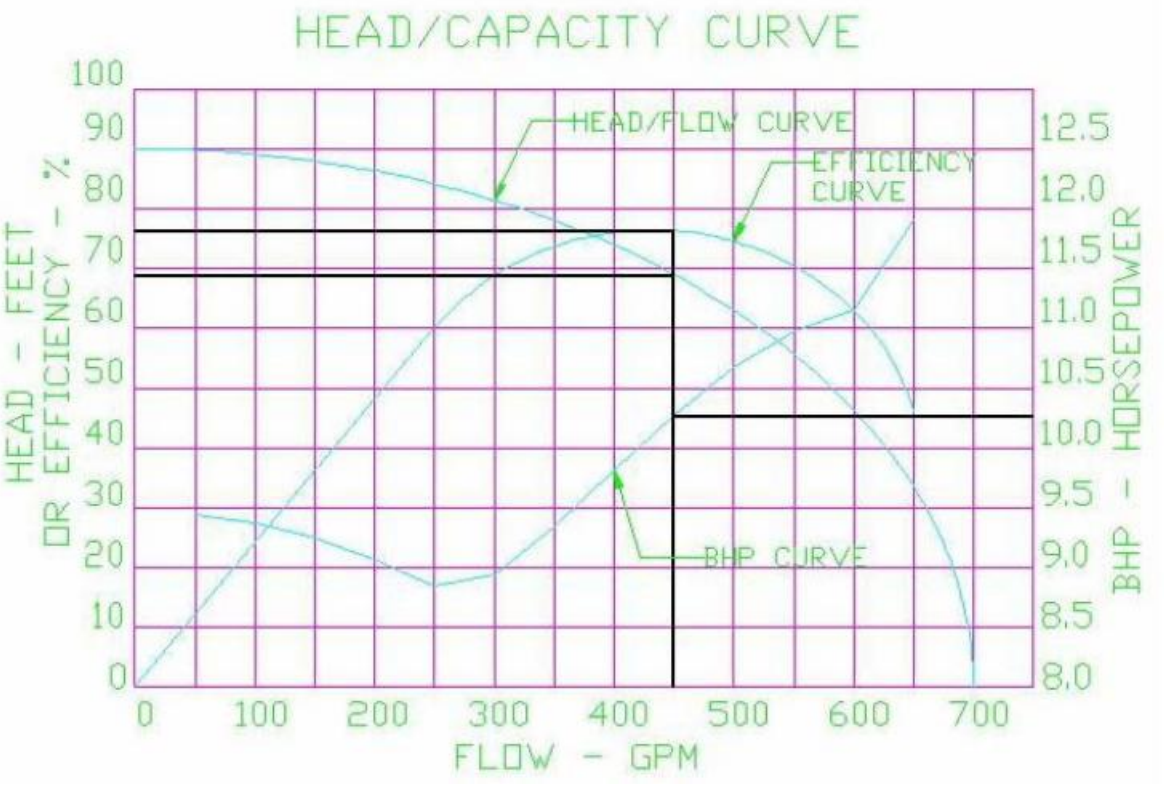


Figure 72. Head capacity curve

For example, on the pump curve shown in Figure 4.2, that pump will operate at 69 feet of head when delivering 450 gpm. When operating at that point, the pump efficiency would be 76% and brake horsepower would be 10.3 HP.

Performance parameters – positive displacement

- Pump curve
- Pressure gauges
- Flow mete

Performance parameters test

- Test performance annually

Document annual testing

In a pumping plant evaluation, an estimation or direct measure of discharge pressure (Pd) and pumping water level (PWL) to determine total dynamic head (TDH) is required. In addition pumping flow rate (Qw), and energy consumption rate must be measured.

Refer the following you tube video link for pump curves

https://www.youtube.com/watch?v=fiJeOLkLV5I

Self-Check -1	Written Test

Direction I: Short answer (18 points)

Instruction: Give short answer for the following questions and write your answer sheet provided in the next page:

1. Draw and explain about the head capacity curve?(10 points)
2. List down the performance parameters of centrifugal pump? (4 points)
3. List down the performance parameters of positive displacement pump? (4 points)

Note: **Satisfactory rating - 9 points and above** **Unsatisfactory - below 9 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-5

Score = _____

Rating: _____

Name: _____ **Date:** _____

Direction I: Short answer questions

1. ……
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2. ……
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3. ……
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   ……

Information Sheet-2	Identifying and applying monitoring points and timing

2.1 Pump station monitoring

Monitoring is the regular observation and recording of activities taking place in a project or programme. It is a process of routinely gathering information on all aspects of the project.

To monitor is to check on how project activities are progressing. It is observation; systematic and purposeful observation.

Monitoring also involves giving feedback about the progress of the project to the donors, implementers and beneficiaries of the project.

Reporting enables the gathered information to be used in making decisions for improving project performance

The main purpose of pump station monitoring is to conduct a general survey of irrigation pumping plant performance.

2.2 Identifying and applying monitoring points and timing

The two important monitoring parameters of pump stations are the **flow rate** and the **pressure** of the system. So routine inspection of the flow rate and Inspections to identify infiltration and obstructions are important points that should be considered while identifying and applying monitoring points and timing

Self-Check -2	Written Test

Direction I: True or false item (2 points each)

Instruction: Write true if the statement is true False otherwise for the following questions and write your answer sheet provided in the next page:

1. Monitoring is the regular observation and recording of activities taking place in a project or programme.
2. To monitor is to check on how project activities are progressing and taking corrective action.
3. The two important monitoring parameter of pump stations are water quality and application efficiency.

Note: **Satisfactory rating - 3 points and above** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-2

Score = _____
Rating: _____

Name: _____ **Date:** _____

Direction I: True of false item

1. ……
2. ……..
3. ……

Information Sheet-3	Monitoring pump station and making adjustments, where necessary, to maintain operational parameters

3.1 monitoring pump station and make adjustment

Monitoring pump station is used to making adjustments, where necessary, to maintain operational parameters

A pump monitor is an automated, field level control system which uses a variety of automated instrumentation to provide operational pumping plant information. Rather than a traditional instantaneous pumping plant test, a pump monitoring system allows a continuous pumping plant evaluation to occur.

The pump monitor developed by Diesel Engine Motors uses a system of sensors including a propeller flow meter, pressure sensor, and a diesel fuel flow sensor or combination of current transformers and voltage measurement equipment to measure all of the parameters necessary for a pumping plant evaluation. As described above, a pumping plant evaluation is a method of testing which allows components of a pumping plant to be evaluated in terms of efficiency. This helps in determining when component(s) should be resized, replaced, and gives an idea of the general economics associated with a pumping plant.

Pumping Plant Performance Testing.

Irrigation pumping plant performance testing requires an accurate instantaneous measurement of Pd, PWL, Qw, and input energy consumption rate. If these parameters can all be measured, work done by pumping plant system on the water can be determined.

Ideally five parameters should be monitored to understand how a pump is performing: suction pressure, discharge pressure, flow, pump speed, and power.

At a minimum, suction and discharge pressure are essential for determining the Total Dynamic Head (TDH) of the pump and the available Net Positive Suction Head (NPSHa). Understanding the pump TDH is critical to estimating where the pump is running with respect to BEP. The suction and discharge pressure are measured by either pressure transducers that can transmit real-time data or pressure gauges.

There are limitations using just suction and discharge pressure measurements. If the pump is operated by a variable speed device, pump speed must be factored in using the affinity laws, which state the change in TDH is proportional to Speed^2. It is also difficult to determine pump wear. As the pump wears and internal clearances increase the pump's ability to generate pressure will decrease.

Without additional information, this decrease in pressure could be interpreted as a change in the process conditions and not necessarily a worn pump.

An accurate power measurement, in combination with suction and discharge pressure readings, can be a powerful tool in assessing pump performance. While current transducers offer the most basic and cost effective power monitoring solution, apply their readings cautiously. Motor amps are not directly proportion to load. Factors such as input voltage, power factor and motor efficiency should be considered to accurately determine the actual shaft horsepower being transmitted to the pump.

voltage pump load monitors offer unsurpassed protection for underload and overload conditions that most often result in mechanical seal damage or pump failure. Pump speed also plays a factor in centrifugal pump load monitoring and the change in power is proportional speed^3. Additionally, changes to the fluid properties such as specific gravity and viscosity can have an impact on pump power and should be considered. Combining both suction and discharge pressure with load monitoring can prove very effective to understanding where the pump is operating with respect to BEP.

In the ideal world, flow measurements could be obtained on all pumps. However, this often proves impractical, but vital for understanding overall pump efficiency. In some installations, permanent flow meters are installed to make the job of monitoring easier. Make sure these flow meters are working properly and have been calibrated on a regular schedule.

When all of the above parameters are known, it becomes a simple matter of calculating pump performance. There are instances when it is very difficult, if not impossible, to determine all of the above parameters in the field. In these cases, the field engineer must rely on his or her ability to understand where a compromise must be made to get the job done. The basic document the field engineer must have is the pump performance curve.

Flow recorders may supplement the flow meter device to record pump performance, condition of pump, and energy usages rates. For complex installations, flow recorders may be part of a remotely located controller or part of remote stations which monitor other data such as speed indication, vibration monitoring, and bearing or casing temperature indicators. Flow recorders will be used to indicate flow fluctuations over the course of a day.

Self-Check -3	Written Test

Direction I: True or false item (2 points each)

Instruction: Write true if the statement is true False otherwise for the following questions and write your answer sheet provided in the next page:

1. Monitoring pump station is used to making adjustments, where necessary, to maintain operational parameters.
2. Flow recorders may supplement the flow meter device to record pump performance, condition of pump, and energy usages rates

Note: **Satisfactory rating - 2 points and above** **Unsatisfactory - below 2 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-3

Score = _____
Rating: _____

Name: _____ **Date:** _____

Direction I: True of false item

1. ……..
2. ……

Operation Sheet -1	Adjusting pressure at pressure valve

Procedure of adjust pressure at valve

Steps

Step 1: Locate the supply line

Step 2: Located the line you will be able to find the water meter.

Step 3: Find the valve

Make sure that your supply line has sufficient pressure before adjusting the pressure valve.

Step 4: Adjusting the Screw

Now that you have located the valve and the screw, you need to loosen the locknut all the way. The screw is your adjuster and it can be maneuvered only by loosening the locknut. The screw acts as a water pressure regulator. If you tighten the screw the water pressure will be more and if you loosen the screw the water pressure will be less. Turn the screw clockwise to tighten it and increase the pressure, or turn it counterclockwise to decrease the pressure.

Step 5: Tighten the Screw Slowly

Do not be too hasty. You need to tighten the screw little by little, in slow increments. Check the result each time you tighten the screw. If the water pressure is too high, it could result in leaks and the toilets to run all the time.

Motoring the faucets in the system to see if there is a change in the pressure compared to before. If you find that after adjusting the pressure valve there is no significant improvement, your valve might be faulty and will need to be replaced.

Step 6: Test for leakage

Once you have successfully adjusted the pressure valve or replaced the valve make sure there is no leakage.

Operation Sheet -2	Monitoring pump stations

Techniques of Check pressure level at pumps

Steps

Step 1: Operate the pump and take readings on the flow meter as well as the two pressure gauges.

Step 2: Determine the pumping head by subtracting the suction pressure from the delivery pressure (if the suction pressure is a negative it will thus be added).

Step 3: Plot the flow rate and delivery pressure on the pump's head-flow curve that should be on record, or can be obtained from manufacturers.

Step 4: Record the result and match it with the standard. This point plots on or close to the original pump curve, the pump is still operating on its original curve otherwise it needs adjustment.

Step 5: Report the result to the responsible personnel.

Operation Sheet -3	Performing pump performance test

Procedure of Pump Performance Test

Steps

Step 1: Prepare the original pump curve sent by supplier.

Step 2: Make sure that the suction strainer is clean and the suction valve is fully open.

Step 3: Ensure that discharge valve is fully closed.

Step 4: Start the centrifugal pump take the reading of the discharge pressure, flow rate, suction pressure and pump Ampere. (Finish this procedure in less than 1 min. As not to damage the internal parts of the pump)

Step 5: Open the discharge valve slightly till the flow rate reaches the first value indicated in pump performance curve provided by pump supplier.

Step 6: Write down the discharge pressure, flow rate, suction pressure and pump Ampere.

Step 7: Increase the opening of the discharge valve till you reach the next value indicated in pump performance curve provided by pump supplier.

Step 8: Open the discharge valve in small increments until it is fully open and take the readings of the discharge pressure, flow rate, suction pressure and pump Ampere at each of the steps.

Write down all the reading you take in a table as shown:-

	1	2	3	4	5
Q(m3/hr)					
Suction P(bar)					
Discharge P(bar)					
Differential head(m)					
Ampere					

Step 8: Compare the curve plotted from pump performance test readings (table) with the performance curve sent by supplier and observe for any differences. If you witness any deviation try to locate the problem and fix it then repeat the test and compare the results.

LAP Test -1	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished:** _____

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks at irrigation pump station area within *30 hours.*

Task 1: Adjust pressure at pressure valve

Task 2: Monitor pump station

Task 2: Perform pump performance test

Instruction Sheet	Learning Guide 55: finalize work

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Checking, maintaining and storing equipment, tools and materials according to manufacturer guidelines and organisational procedures.
- Restoring work site to meet environmental and organisational requirements.
- Maintaining workplace records as required.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Check, maintain and store equipment, tools and materials according to manufacturer guidelines and organisational procedures.
- Restore work site to meet environmental and organisational requirements.
- Maintain workplace records as required.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 3”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2, and 3 ” in each information sheets on pages 28, 173, 177 and 182.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1 and 2 on pages 184 and 185 do the LAP Test on page 187”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next UC.

Information Sheet-1	Checking, maintaining and storing equipment, tools and materials

1.1 Checking, maintaining and storing equipment, tools and materials

As the final step tools and equipments should be check if they are Brocken, maintained, cleaned and stored in proper place. Proper care and maintenance of tools prolongs their lifespan, and will help to ensure that they work properly. Follow these guidelines:

General tool maintenance and storage guideline

- All tools require regular maintenance to work properly.
- Clean all tools after each use with water and treat with a penetrating oil to prevent rust.
- Tools that require a sharp edge must be sharpened regularly as sharp tools are safer and more efficient to use.
- Various sharpening methods are used depending upon the tool. It is important to become familiar with the methods relevant to the tools you use.
- Check tools regularly for loose nuts and screws and tighten as needed.
- After use, wash, clean and dry the tools if required , otherwise wipe them with a rag
- Sand rough handles and repair cracks as soon as they are noticed to prevent injury
- Keep grease guns and oil cans free of sand and grit
- Always wipe the tip of the grease gun before use to remove any sand or grit.
- Wipe off excess grease and oil after use, and after filling the cans.
- Store tools in a dry area out of the elements.
- Tools must be stored in a shed or an enclosed area that can be locked.
- A stain-resistant floor and considerable storage in the form of cabinets, hooks and shelving racks (for hand tools and equipment) – suspended from painted walls – will transform a disorganised space into a neat and tide one

Reporting problems and defective tools

Broken or damaged tools can cause injury or accidents in the workplace. The quicker problems are reported, the quicker the tool can be fixed or replaced and the less the risk or injury.

Broken or incomplete tools must not be used but placed in a special place for it to repaired or adapted. This will prevent injury and will enhance the life of the tool. Persons with proper training and skill should repair tools. Preventative maintenance like fastening loose nuts or shafts will greatly reduce the need for large-scale repairs.

Routine maintenance of tools

Routine maintenance: Routine maintenance tasks refer to on-going, scheduled tasks that are performed in order to keep hand tools and basic equipment functioning properly. It could include tasks such as unblocking pipes and nozzles, sharpening blunt tools, cleaning nozzles on sprayers, checking water and oil levels in machinery, cables and plugs.

Routine maintenance tasks

What follows is a check list for routine maintenance. Complete a visual inspection:

Table 5. visual inspection of chelist for tools

	Tool	yes	no
1	Are tools in safe condition?		
2	Are instruction manuals available?		
3	Are power tools properly grounded?		
4	Are guards and shields in place?		
5	Is Personal Protective Equipment available?		
6	Are tools properly stored?		

Scheduling routine maintenance

Reporting faults and problems:

Every farm has a different maintenance schedule and it is important that you are familiar with the schedule implemented on the farm where you work. There will usually be a routine schedule for particular tools that states how often maintenance checks have to be performed. These will also specify the checks that have to be performed. Some tools may require daily checks and maintenance after use. Other tools, such as power tools, usually must be checked once in 6 months or so.

More complicated power tools would need to be serviced on a regular interval; refer to the operation manual. A **maintenance schedule** assigns a specific date to specific

maintenance tasks. It states what has to be checked and will require that the assigned person signs off the document assuring that the checks were done. If faults are found, the tool must be sent for maintenance and the assigned person that fixes the tool has to report on exactly what was done and when it was completed.

An example of a checklist is given below:

Date	Tool	Maintenance check points	Signature	Maintenance required	Signature
14-10	Spades	Handle	Peter	None	
		Shaft	Peter	Splinters shaved off	Manie
		Blade	Peter	None	

Maintenance performed	Date	Signature
Splinters shaved off	16-10	Manie

Table 6. tools maintenace schedule checklist

Self-Check -1	Written Test

Direction I: Short answer type

Instruction: Give shot answer for the following questions and write your answer on the answer sheet provided in the next page: (14 points)

1. Prepare a checklist of Scheduling routine maintenance?(10 points)
2. List down some routine maintenance task of tools and equipments? (4 points)
3. How do you report problem or defect tools? (2 points)

Direction II: Multiple choice types

Instruction: Choose the best answer from the alternatives of following questions and write your answer on the answer sheet provided in the next page: (2 points each)

1. Select the true statement about maintenance of tools and equipments

   A. All tools require regular maintenance to work properly.

   B. Clean all tools after each use with water and treat with a penetrating oil to prevent rust.

   C. Tools that require a sharp edge must be sharpened regularly as sharp tools are safer and more efficient to use.

   C. All

2. Select the false statement about storage of of tools and equipments

   A. Store tools in a dry area out of the elements.

   B. Tools must be stored in a shed or an enclosed area that can be locked.

   C. A stain-resistant floor and considerable storage in the form of cabinets, hooks and shelving racks should be used

   D. Tools can be store outside visible to sun light

Note: **Satisfactory rating - 9 points and above** **Unsatisfactory - below 9 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Score = _____
Rating: _____

Name: _____ Date: _____

Give short answer

1. .....
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2. .....
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3. .....
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   .....
   ....

Multiple choices

1.....

2.....

Information Sheet-2	Restoring work site

2.1 Restoring work site

At the completion of any operation and maintenance of pump stations work site should be restored and environmental management should be practiced. All things which disturb the environment as the result of irrigation and drainage pump station operation and maintenance should be cleared off site.

On completion of operations and maintenance work, the entire site shall be cleared of all debris, leftover greases and oils, excess pipe pieces, and ground surface shall be finished to a neat workman like appearance. All damages done to the environment during the course of the operation and maintenance service should be restored as its regional position.

All existing surface improvements and site conditions disturbed or damaged during operation and maintenance activity to be restored to a condition equal to pre-existing condition.

Cleaning up spills

Clean up spilt oil and grease as soon as possible after the contamination is noticed. Oil and grease spills present a safety hazard and their clean up should be given priority. Suitable materials should be used to clean up spills.

Suggested materials are:

- Absorbent media (kitty litter type) to soak up large spills
- Rags to absorb small quantities
- Degreasing fluid to remove oily films

Clean up of spent lubricant

Due to automatic lubrication of the machines, used lube will build-up around gear sets, bearings, slides and sheaves. Regular cleanup is required to ensure a safe environment and to avoid dirt build-up that can contaminate machine components. Particular attention should be paid to bearing grease collection trays, floor areas under machines. Leaking distributor blocks, fittings and hoses should be reported as soon as possible to affect repairs and avoid further contamination of the machine and the environment.

The cleaning process

- Sweeping, including manual, walk-behind and ride-on
- Vacuuming, including wet and dry
- Hosing down, including pressure and high-pressure washing
- Air blowing
- Scrubbing, washing, wiping, spot cleaning, rinsing and pre-spraying
- Stripping, re-sealing and polishing
- Blasting, including sand, water, steam, powder and dry ice
- Mopping, including wet and dry
- Wet and dry area cleaning.

Return area to operational condition

The following listed point's shows what things should be considered in returning the pump station area to the operational condition

- Replacing items that were moved back into original position
- Replacing items into designated positions as identified by work orders
- Cooperating with other staff to establish a suitable operational area at the start of shift/trade
- Removing barriers and signage
- Opening the site/area for staff and public access, as appropriate
- Notifying relevant supervisors of operational readiness of area.

Self-Check -2	Written Test

Direction I: True or false item (2 points each)

Instruction: Write true if the statement is true False otherwise for the following questions and write your answer sheet provided in the next page:

1. Regular cleanup is required to ensure a safe environment and to avoid dirt build-up that can contaminate machine components.
2. Clean up spilt oil and grease as soon as possible after the contamination is noticed.
3. At the completion of any operation and maintenance of pump stations work site should be restored and environmental management should be practiced.
4. Removing barriers and signage should not be considered as things that should be considered in returning the pump station area to the operational condition.

Note: **Satisfactory rating - 4 points and above** **Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-2

Score = _____
Rating: _____

Name: _____ **Date:** _____

Direction I: True or False item

1. ……..
2. ……
3. ……
4. ……

Information Sheet-3	Maintaining workplace records as required

3.1 Introduction to workplace records

3.1.1. Definitions of a Record

1. Document that memorializes and provides objective evidence of activities performed, events occurred, results achieved, or statements made. Records are created/received by an organization in routine transaction of its business or in pursuance of its legal obligations. .

2. All documented information, regardless of its characteristics, media, physical form, and the manner it is recorded or stored. Records include accounts, agreements, books, drawings, letters, magnetic/optical disks, memos, micrographics, etc. Generally speaking, records function as evidence of activities, whereas documents function as evidence of intentions.

1.1.2. Purposes of records

Reasons for record keeping include in irrigation system:

- Legal requirements
- Contractual requirements
- To control work
- To provide data for future work

2.2. Maintaining workplace Records

An operator of irrigation and drainage pump station is responsible for different tasks. The final step of his/her task should be documenting the result and reporting to the responsible person.

Routine record keeping is accomplished by utilizing the following reports:

- Monthly operating report
- Daily start-up checklist
- Weekly/Monthly inspection report
- Maintenance activity report
- Incident/Follow-up action report
- Annual consumers' confidence report

The Monthly Operating Report is used to maintain daily records of water pump age, chemical quantities, and routine test results.

A copy of the Daily Start-up Checklist should be kept. The form should be used to ensure that start-up activities are properly conducted, especially in the event of an emergency when the regular operator is not available. This report is not required to be submitted to the Bureau but should be kept on-site for review upon request.

The Weekly/Monthly Inspection Report can be used to document weekly and/or monthly inspections of mechanical equipment and appurtenances. Weekly/monthly inspections will ensure that the system is operating properly and in compliance with all applicable rules, regulations, and permit conditions. This report is not required to be submitted to the Bureau but should be kept on-site for review upon request.

The Maintenance Activity Report can be used to document preventative maintenance and testing activities, based on the manufacturer's recommendations and specifications for equipment. This report is not required to be submitted to the Bureau but should be kept on-site for review upon request.

The Incident/Follow-up Action Report can be used to record follow-up measures taken to correct any deficiencies noted during daily, weekly or monthly inspections. This report is not required to be submitted to the Bureau but should be kept on-site for review upon request.

The annual Consumers Confidence Report must be delivered to your customers with a copy to the Bureau.

Inspection of:	**Observations/Initials**	**Date / Time**

Table 8.Weekly / Monthly Inspection Report

Initials / Date	Activity Performed:	Location

Table 9. Maintenance Activity Report

Incident/Follow-up Action Report

This report documents all breaks, breakdowns, problems, bypasses, pump failures, occurrences, emergencies, complaints and/or intervening factors that result in or necessitate deviation from routine O&M procedures, and any situations that have the potential to affect public health, safety, welfare, or the environment or have the potential to violate any permits, regulations or laws relating to the water system. In addition, this report records the remedial or follow-up action taken to correct the circumstance.

Follow Up Action and/or Incident/complaint	Corrective Action Taken	Initials	Date/Time

Table 10. Incident report form

Self-Check -3	Written Test

Direction I: Short answer item

Instruction: Give short answer for the following questions and write your answer on the answer sheet provided in the next page.

1. List down the type routine records during operation and maintenance of irrigation system? (5 points)
2. What are the Reasons for record keeping include in irrigation system? (3 points)
3. Define records? (2 points)

Note: **Satisfactory rating - 5 points and above** **Unsatisfactory - below 5 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet-3

Score = _____

Rating: _____

Name: _____ **Date:** _____

Direction I: Short answer

1. ……
   ……
   ……
   ……
2. ……
   ……
   ……
   ……
3. ……
   ……
   ……
   ……

Operation Sheet -1	Maintaining tools and equipments

Procedure of maintaining tools and equipments

Steps

Step 1: Select and wear appropriate PPE

Step 2: Using water and treat with a penetrating oil to prevent rust clean tools and equipments.

Step 3: Clean your tools. Cleaning the tools regularly is essential to their proper functioning. Maintain tools and equipments regularly

Step 4: After use, wash, clean and dry the tools if required otherwise wipe them with a rag

Step 5: sharpened tools regularly that require sharpening

Step 6: tighten for loose nuts and screws as needed

Step 7: Lubricate tools

Step 8: Store tools properly

Operation Sheet -2	Storing of tools and equipment

Technique of storing tools and equipment

Steps

Step 1: Clear out the junk

Sort out and discard all the junk that you do not need: keep only what you use and remove everything else that is still useful, but might belong in a different storage area. Throw away anything that is broken and just taking up space.

Step 2: Paint the walls and floors

Take measurements and draw a floor plan to help you visualise what will fit and where it can be placed. Don't forget to consider the walls for storage. This is also the ideal chance to paint the walls, especially if they are currently exposed plaster or brick walls. Use lighter colours in smaller spaces to make these appear bigger.

You may want to consider painting the floor before you start installing storage systems and moving everything back into the store. Preferably use an epoxy paint that is designed for floors.

Get started

1. Before painting your floor, clean it thoroughly and use a degreaser to remove any grease or oily residue that could prevent the paint from adhering. Clean the floor thoroughly with the cleaning solution provided, or use a sugar-soap solution or to remove grease stains and dirt. Wash the floor with water and let it dry.

2. Mix the two parts of the epoxy kit. Allow it to stand for the required amount of time before you apply it.

3. Use a medium pile roller and broom-handle attachment to apply the epoxy floor coat. First paint along the sides of the garage, leaving a channel down the middle of the floor.

4. Paint the channel last. Follow the recommended drying times on the pack. It is usually recommended that you wait between 16 and 24 hours for it to dry before you walk on the newly painted floor, but it' s a good idea to wait 48 hours or longer before you move vehicles or large equipment onto the surface.

Step 3: Storing smaller and larger items

Shelving is vital keeping things in containers not only lets you get them off the workbench or the floor but also keeps them clean and dust free. Always label opaque containers so you know what is inside them. Allocate space for hand tools separately from other equipment large item. Decide which items you need to use often, such as hand tools, and store these near the door.

Step 4: Organise your work area

Use transparent jars to store smaller items so that you can easily see what they contain.

Step 5: Safety proof your expensive tools such as pliers

Install a lockable latch on a cupboard door to keep expensive items under lock and key.

LAP Test -1	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished:** _____

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 30 hours.

Task 1: Maintain tools and equipments

Task 2: Store tools and equipment

List of reference materials

1. Centrifugal Pumps for General Refinery Services, Refining Department, API Standard 610, 6th Edition, January 1981
2. Centrifugal pumps operation at off - design conditions", Chemical Processing April, May, June 1987, Igor J. Karassik
3. Controlling Centrifugal Pumps, Hydrocarbon Processing, July 1995, Walter Driedger
4. Manual of Water Supply Practices," *American Water Works Association M32 Distribution Network Analysis for Water Utilities*, (AWWA Denver, CO).
5. Trouble shooting Process Operations", 3 rd Edition 1991, Norman P.Lieberman, PennWell Books.
6. Understanding NPSH for Pumps, Technical Publishing Co. 1975, Travis F. Glover
7. Wastewater Treatment Plant Operator Training Module 9: Basics of Pumps and Hydraulics," (PA DEP Bureau of Water Supply and Wastewater Management) (30, Jun. 2003).
8. http://files.dep.state.pa.us/Water/BSDW/OperatorCertification/TrainingModules/fin1_water_supply_instructor_guide.pdf
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16. https://www.wikihow.com/Replace-Mechanical-Seals-in-Centrifugal-Pumps
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Prepared by						
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