Ethiopian TVET-System

Electro Mechanical Equupment And Machinery Maintenance
NTQF Level –II

Based on March, 2017G.C. Occupational Standard

Module Title: - Operating and Monitoring Pump Station

TTLM Code: EIS EME2 TTLM 0920V1

This module includes the following Learning Guides

LG 43: **Plan and prepare work**

LG Code: **EIS EME2 M10 L0 01-LG-43**

LG 44: **Operate pump stations**

LG Code: **EIS EME2 M10 L0 02-LG-44**

LG 45: **Maintain pump stations**

LG Code: **EIS EME2 M10 L0 03-LG-45**

LG 46: **Monitor and adjust pump station performance**

LG Code: **EIS EME4 M10 L0 04-LG-46**

LG 47: **Check outsourced maintenance work**

LG Code: **EIS EME4 M10 L0 05-LG-47**

LG 48: **Finalise work**

LG Code: **EIS EME4 M10 L0 06-LG-48**

Instruction Sheet 1	Learning Guide 43: Plan and Prepare work

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

- Identifying types of pumps and pumping principles
- Determining pump station work requirements from standard operating and maintenance procedures.
- Selecting and checking equipment and tools to meet safety requirements of task and site.
- personal protective equipment

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 types of pumps and pumping principles
- Determine Pump station work requirements from standard operating and maintenance procedures.
- Select and check Equipment and tools.
- Select, fit and use personal protective equipments

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.
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-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
7. Submit your accomplished Self-check. This will form part of your training portfolio.
8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page __.
10. 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-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page __.

13. 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-check 3).
14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” . However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Activities.

Information Sheet-1	Identifying types of pumps and pumping principles

Introduction

Water pumps are water-lifting devices used to lift water to a height that allows users easy access to water. Lifting devices can be used to raise groundwater, rainwater stored in an underground reservoir, and river water. Communities should be able to choose from a range of water-lifting devices, and each option should be presented with its advantages, disadvantages and implications. For example, water lifting involves additional O&M activities and potential problems, compared to gravity systems, and the latter are often preferred if they are available and applicable to the situation.

1 Main pump types

There are two main pump types –positive displacement and centrifugal. Our focus is mainly on centrifugal pumps as they are by far the most commonly used pumps, particularly in water supply applications

1.1 Positive displacement pumps

- Reciprocating
- Rotary

1.2 Dynamic pumps

- Centrifugal pumps
- Jet pumps

1.1 Positive displacement pumps

1.1.1 Reciprocating pumps

Reciprocating pumps are positive displacement pumps and are based on the principle of the 2000-year-old pump made by the Greek inventor, Ctesibius.

Plunger pumps

Plunger pumps comprise of a cylinder with a reciprocating plunger in it (Figure 1.1). The head of the cylinder houses the suction and the discharge valves.

In the suction stroke, as the plunger retracts, the suction valve opens causing suction of the liquid within the cylinder.

In the forward stroke, the plunger then pushes the liquid out into the discharge header. The pressure built in the cylinder is marginally over the pressure in the discharge.

The gland packing help to contain the pressurized fluid within the cylinder. The plungers are operated using the slider-crank mechanism. Usually, two or three cylinders are placed alongside and their plungers reciprocate from the same crankshaft. These are called as duplex or triplex plunger pumps.

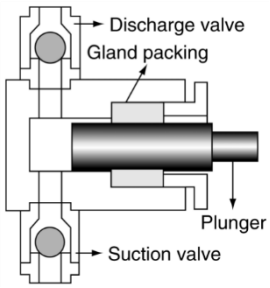


Figure 1.1 *Plunger pump*

1.1.2 Diaphragm pumps

Diaphragm pumps are inherently plunger pumps. The plunger, however, pressurizes the hydraulic oil and this pressurized oil is used to flex the diaphragm and cause the pumping of the process liquid.

Diaphragm pumps are primarily used when the liquids to be pumped are hazardous or toxic. Thus, these pumps are often provided with diaphragm rupture indicators.

Diaphragm pumps that are designed to pump hazardous fluids usually have a double diaphragm which is separated by a thin film of water (for example, see Figure 1.2). A pressure sensor senses the pressure of this water. In a normal condition, the pressure on the process and oil sides of the diaphragms is always the same and the pressure between the diaphragms is zero.

Figure 1.2 *Double diaphragm pumps (Lewa pumps)*

However, no sooner does one of them ruptures than the pressure sensor records a maximum of process discharge pressure. The rising of this pressure is an indicator of the diaphragm rupture

Even with the rupture of just one diaphragm, the process liquid does not come into contact with the atmosphere.

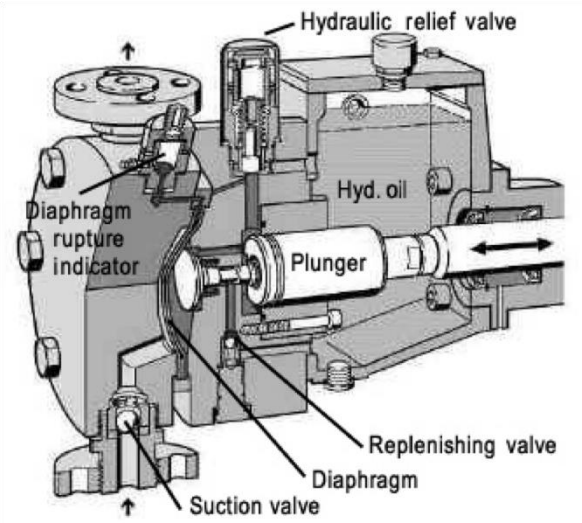


Figure 1.3 *Diaphragm pump*

1.1.2 Rotary pumps

Gear pump

Gear pumps are of two types:

1. External gear pump
2. Internal gear pump.

External gear pump

In external gear pumps, two identical gears rotate against each other. The motor provides the drive for one gear. This gear in turn drives the other gear. A separate shaft supports each gear, which contains bearings on both of its sides (Figure 1.4).

As the gears come out of the mesh, they create expanding volume on the inlet side of the pump. Liquid flows into the cavity and is trapped by the gear teeth while they rotate.

Liquid travels around the interior of the casing in the pockets between the teeth and the casing. The fine side clearances between the gear and the casing allow recirculation of the liquid between the gears.

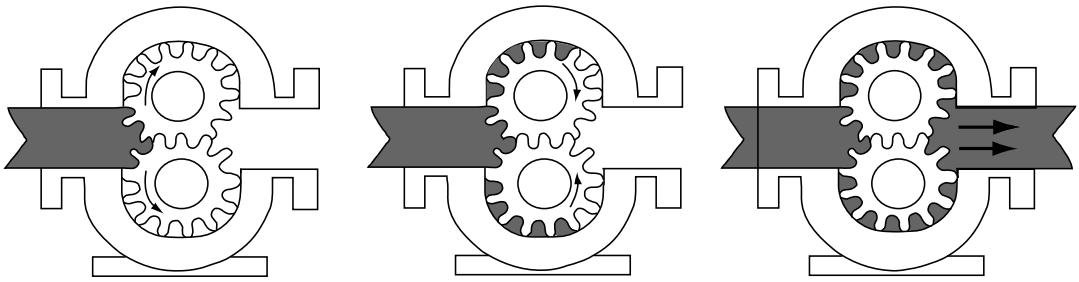


Figure 1.4
External gear pump

Finally, the meshing of the gears forces liquid through the outlet port under pressure. As the gears are supported on both sides, the noise levels of these pumps are lower and are typically used for high-pressure applications such as the hydraulic applications.

Internal gear pump

Internal gear pumps have only two moving parts (Figure 1.5). They can operate in either direction, which allows for maximum utility with a variety of application requirements.

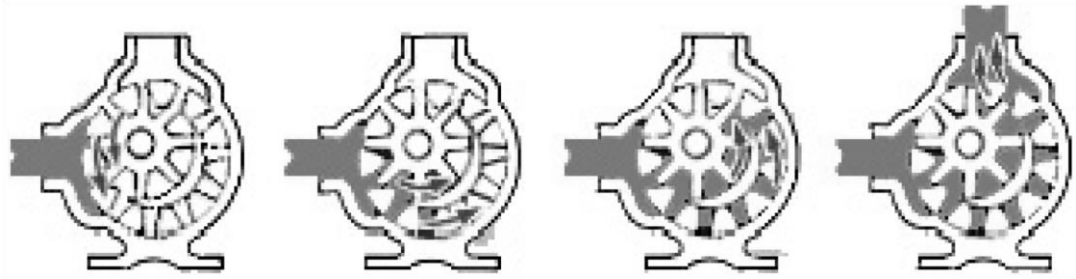


Figure 1.5*Internal gear pump*

In these pumps, liquid enters the suction port between the large exterior gears, rotor, and the smaller interior gear teeth, idler. The arrows indicate the direction of the pump and the liquid.

Liquid travels through the pump between the teeth of the 'gear-within-a-gear' principle. The crescent shape divides the liquid and acts as a seal between the suction and the discharge ports.

The pump head is now nearly flooded as it forces the liquid out of the discharge port.

Rotor and idler teeth mesh completely to form a seal equidistant from the discharge and suction ports. This seal forces the liquid out of the discharge port.

The internal gear pumps are capable of handling liquid from very low to very high viscosities. In addition to superior high-viscosity handling capabilities, internal gear pumps offer a smooth, non-pulsating flow. Internal gear pumps are self-priming and can run dry.

Lobe pump

The operation of the lobe pumps is similar to the operation of the external gear pumps (Figure 1.6). Here, each of the lobes is driven by external timing gears. As a result, the lobes do not make contact.

Pump shaft support bearings are located in the gearbox, and since the bearings are not within the pumped liquid, pressure is limited by the location of the bearing and shaft deflection.

As the lobes come out of mesh, they create expanding volume on the inlet side of the pump. The liquid then flows into the cavity and is trapped by the lobes as they rotate.

The liquid travels around the interior of the casing in the pockets between the lobes and the casing and it does not pass between the lobes.

Finally, the meshing of the lobes forces the liquid through the outlet port under pressure. Lobe pumps are frequently used in food applications because they can handle solids without damaging the product. The particle size pumped can be much larger in lobe pumps than in any other of the PD types.

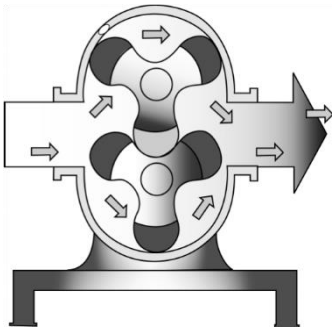


Figure 1.6 *Lobe pump*

Vane pump

A vane pump too traps the liquid by forming a compartment comprising of vanes and the casing (Figure 1.7). As the rotor turns, the trapped liquid is traversed from the suction port to the discharge port.

A slotted rotor or impeller is eccentrically supported in a cycloidal cam. The rotor is located close to the wall of the cam so a crescent-shaped cavity is formed. The rotor is sealed in the cam by two side plates. Vanes or blades fit within the slots of the impeller. As the impeller rotates and fluid enters the pump, centrifugal force, hydraulic pressure, and/or pushrods push the vanes to the walls of the housing. The tight seal among the vanes, rotor, cam, and side plate is the key to the good suction characteristics common to the Vane pumping principle.

The housing and cam force fluid into the pumping chamber through the holes in the cam. Fluid enters the pockets created by the vanes, rotor, cam, and side plate.

As the impeller continues around, the vanes sweep the fluid to the opposite side of the crescent where it is squeezed through the discharge holes of the cam as the vane approaches the point of the crescent. Fluid then exits the discharge port.

Vane pumps are ideally suited for low-viscosity, non-lubricating liquids.

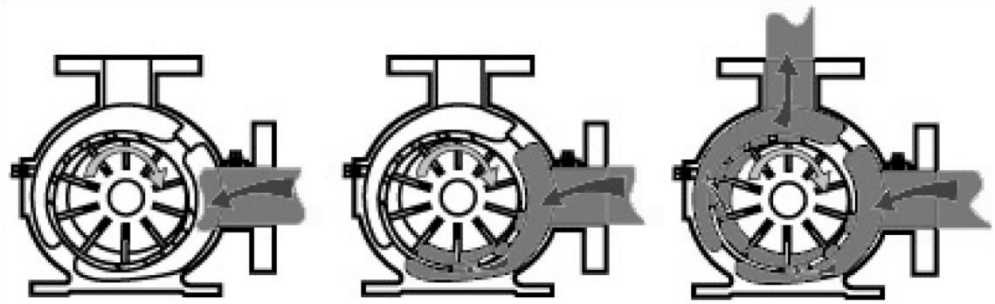


Figure 1.7 *Vane pump*

Progressive cavity pump

A progressive cavity pump consists of only one basic moving part, which is the driven metal rotor rotating within an elastomer-lined (elastic) stator (Figure 1.12).

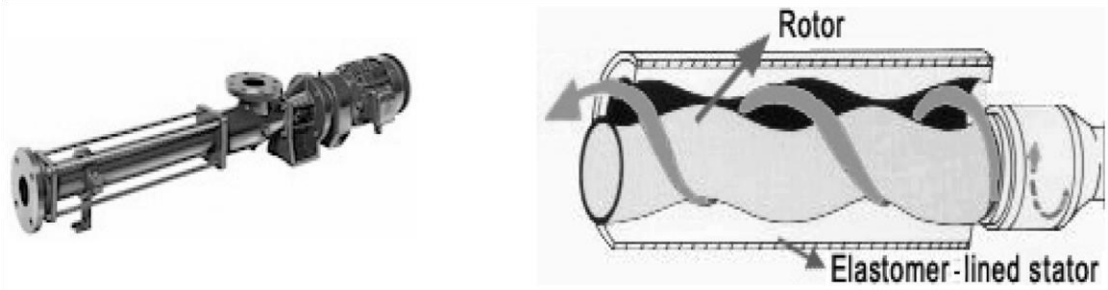


Figure 1.8 *Vane pump progressive cavity pump*

As the rotor turns, chambers are formed between the rotor and stator. These chambers progress axially from the suction to the discharge end, moving the fluid. By increasing the pitch of the rotor and stator, additional chambers or stages are formed.

The Vane pumps are solutions to the special pumping problems of municipal and industrial wastewater and waste processing operations. Industries, such as, chemical, petrochemical, food, paper and pulp, construction, mining, cosmetic, and industrial finishing, find these pumps are ideally suited for pumping fluids with nonabrasive material inclusion.

- Generally positive displacement pumps dispense a set amount of liquid for every revolution of the shaft so that flow is determined by the speed at which the pump is driven
- They are more suited to pumping more viscous or thick liquids and are not always ideal for pumping water
- An example of a positive displacement pump is a piston pump

1.2 Dynamic pumps

- Centrifugal pumps
- Jet pumps

1.2.1 CENTRIFUGAL PUMPS

Centrifugal pumps are the most common type of pumps found in DOE facilities. Centrifugal pumps enjoy widespread application partly due to their ability to operate over a wide range of flow rates and pump heads.

Centrifugal pumps basically consist of a stationary pump casing and an impeller mounted on a rotating shaft. The pump casing provides a pressure boundary for the pump and contains channels to properly direct the suction and discharge flow. The pump casing has suction and

discharge penetrations for the main flow path of the pump and normally has small drain and vent fittings to remove gases trapped in the pump casing or to drain the pump casing for maintenance.

Figure 1 is a simplified diagram of a typical centrifugal pump that shows the relative locations of the pump suction, impeller, volute, and discharge. The pump casing guides the liquid from the suction connection to the center, or eye, of the impeller. The vanes of the rotating *impeller* impart a radial and rotary motion to the liquid, forcing it to the outer periphery of the pump casing where it is collected in the outer part of the pump casing called the volute. The *volute* is a region that expands in cross-sectional area as it wraps around the pump casing. The purpose of the volute is to collect the liquid discharged from the periphery of the impeller at high velocity and gradually cause a reduction in fluid velocity by increasing the flow area. This converts the velocity head to static pressure. The fluid is then discharged from the pump through the discharge connection.

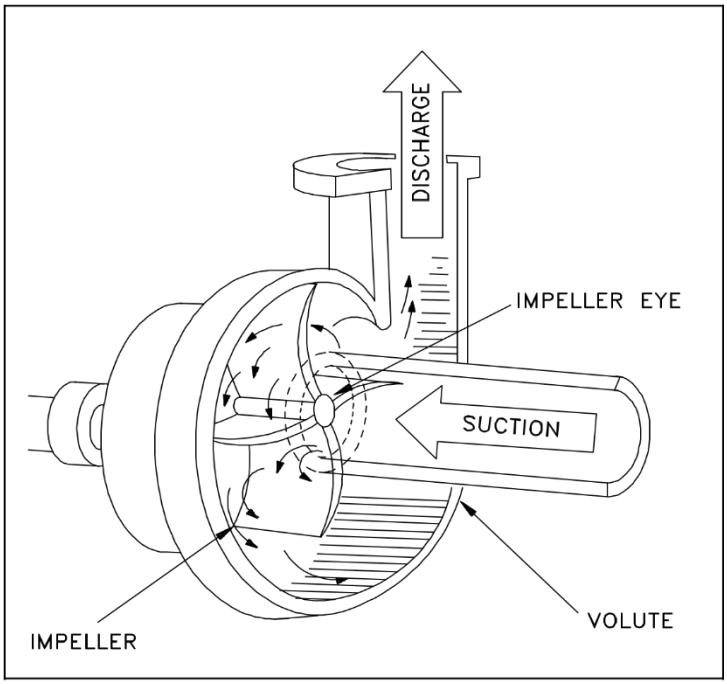


fig 1.9 Centerfugal pump

Centrifugal pumps can also be constructed in a manner that results in two distinct volutes, each receiving the liquid that is discharged from a 180^{o} region of the impeller at any given time. Pumps of this type are called double volute pumps (they may also be referred to a split volute pumps). In some applications the double volute minimizes radial forces imparted to the shaft and bearings due to imbalances in the pressure around the impeller. A comparison of single and double volute centrifugal pumps is shown on Figure 2.

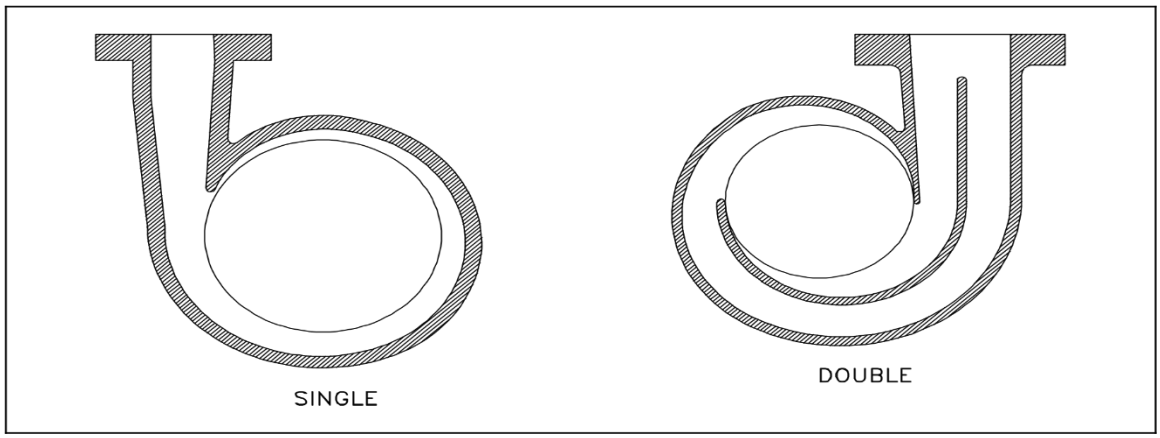


Figure 1.11 Single and Double Volutes

Diffuser

Some centrifugal pumps contain diffusers. A *diffuser* is a set of stationary vanes that surround the impeller. The purpose of the diffuser is to increase the efficiency of the centrifugal pump by allowing a more gradual expansion and less turbulent area for the liquid to reduce in velocity. The diffuser vanes are designed in a manner that the liquid exiting the impeller will encounter an ever increasing flow area as it passes through the diffuser. This increase in flow area causes a reduction in flow velocity, converting kinetic energy into flow pressure.

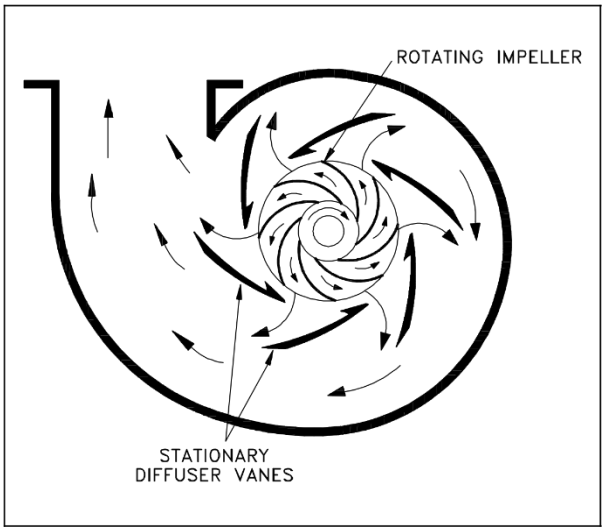


Figure 1.12Centrifugal Pump Diffuser

Classification by Impeller type

Impellers of pumps are classified based on the number of points that the liquid can enter the impeller and also on the amount of webbing between the impeller blades.

Impellers can be either single suction or double-suction. A single-suction impeller allows liquid to enter the center of the blades from only one direction. A double-suction impeller allows liquid to enter the center of the impeller blades from both sides simultaneously. Figure 4 shows simplified diagrams of single and double-suction impellers.

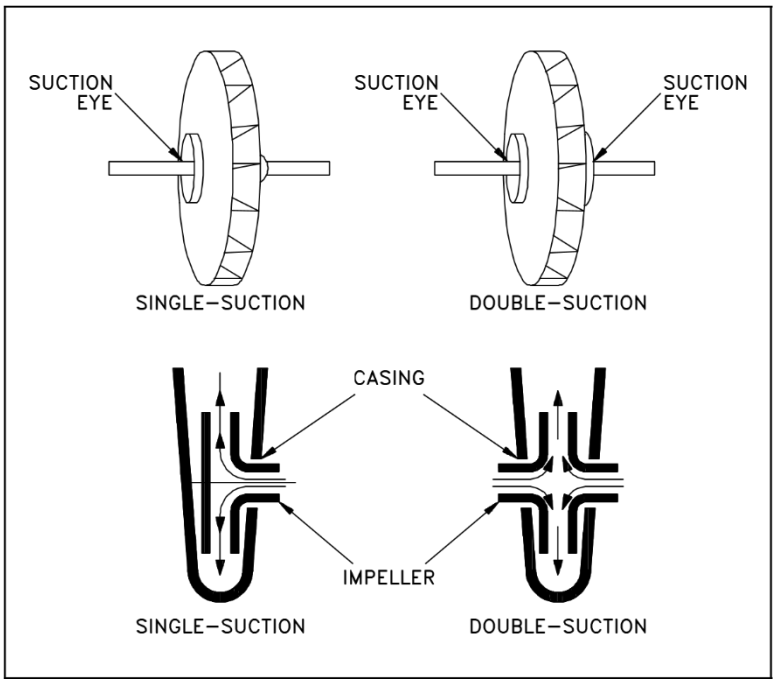


Fig.1.13 Single-Suction and Double-Suction Impellers

Impellers can be open, semi-open, or enclosed. The open impeller consists only of blades attached to a hub. The semi-open impeller is constructed with a circular plate (the web) attached to one side of the blades. The enclosed impeller has circular plates attached to both sides of the blades. Enclosed impellers are also referred to as shrouded impellers. Figure 5 illustrates examples of open, semi-open, and enclosed impellers.
The impeller sometimes contains balancing holes that connect the space around the hub to the

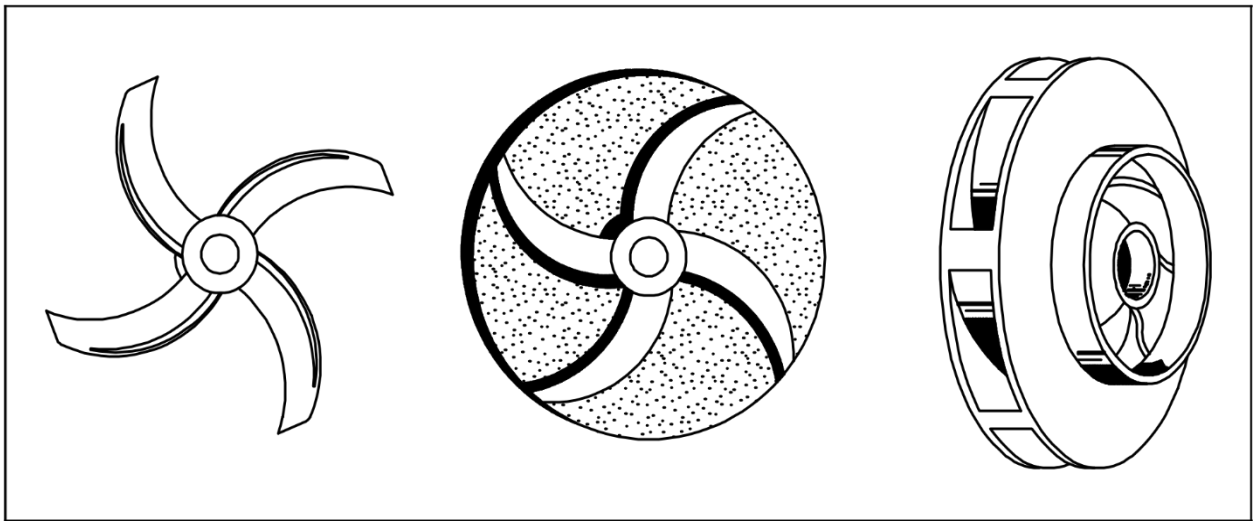


Fig.1.14 open,semi open,and enclosed impellers

suction side of the impeller. The balancing holes have a total cross-sectional area that is considerably greater than the cross-sectional area of the annular space between the wearing ring and the hub. The result is suction pressure on both sides of the impeller hub, which maintains a hydraulic balance of axial thrust.

Classification of centrifugal pumps

Centrifugal Pump Classification by Flow

Centrifugal pumps can be classified based on the manner in which fluid flows through the pump. The manner in which fluid flows through the pump is determined by the design of the pump casing and the impeller. The three types of flow through a centrifugal pump are radial flow, axial flow, and mixed flow.

Radial Flow Pumps

In a radial flow pump, the liquid enters at the center of the impeller and is directed out along the impeller blades in a direction at right angles to the pump shaft. The impeller of a typical radial flow pump and the flow through a radial flow pump are shown in Figure 6.

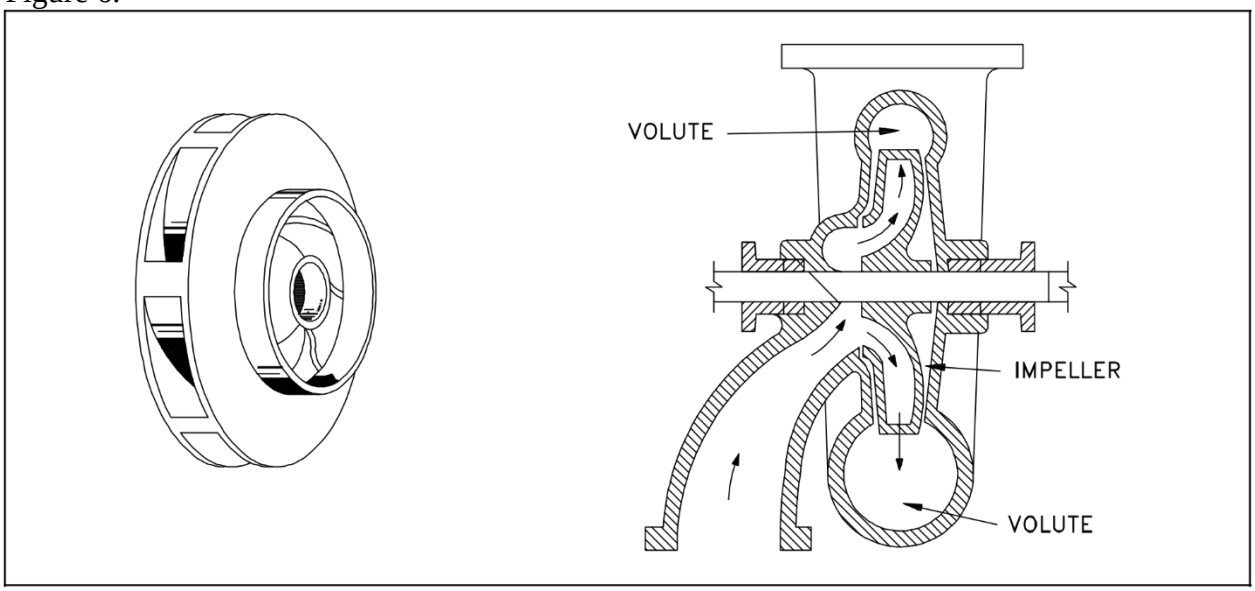


Figure 6 Radial Flow Centrifugal Pump

Axial Flow Pumps

In an axial flow pump, the impeller pushes the liquid in a direction parallel to the pump shaft. Axial flow pumps are sometimes called propeller pumps because they operate essentially the same as the propeller of a boat. The impeller of a typical axial flow pump and the flow through a radial flow pump are shown in Figure 7.

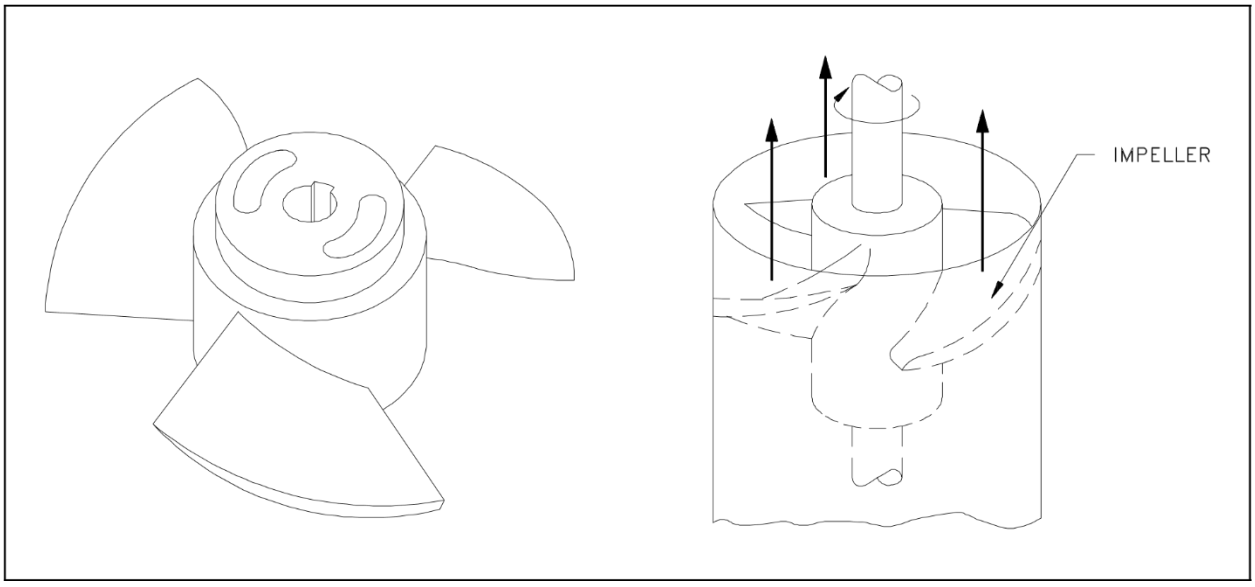


Figure 1.15 Axial Flow Centrifugal Pump

Mixed Flow Pumps

Mixed flow pumps borrow characteristics from both radial flow and axial flow pumps. As liquid flows through the impeller of a mixed flow pump, the impeller blades push the liquid out away from the pump shaft and to the pump suction at an angle greater than 90º. The impeller of a typical mixed flow pump and the flow through a mixed flow pump are shown in Figure 8.

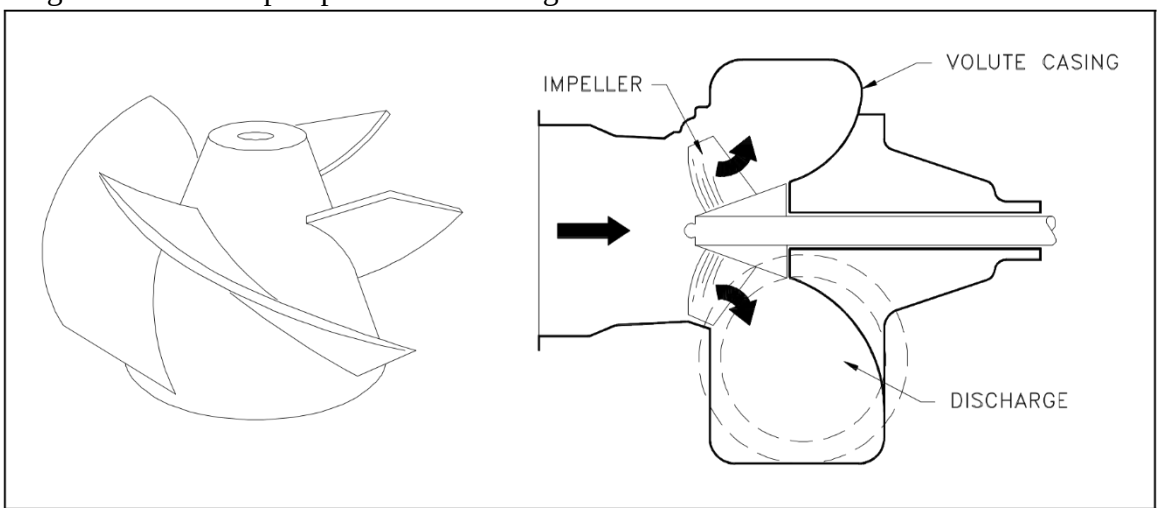


Fig.Mixed flow Centerfugal Pump

Multi-Stage Centrifugal Pumps

A centrifugal pump with a single impeller that can develop a differential pressure of more than 150 psi between the suction and the discharge is difficult and costly to design and construct. A more economical approach to developing high pressures with a single centrifugal pump is to include multiple impellers on a common shaft within the same pump casing. Internal channels in the pump casing route the discharge of one impeller to the suction of another impeller. Figure 9 shows a diagram of the arrangement of the impellers of a four-stage pump. The water enters the pump from the top left and passes through each of the four impellers in series, going from left to right. The water goes from the volute surrounding the discharge of one impeller to the suction of the next impeller.

A *pump stage* is defined as that portion of a centrifugal pump consisting of one impeller and its associated components. Most centrifugal pumps are single-stage pumps, containing only one impeller. A pump containing seven impellers within a single casing would be referred to as a seven-stage pump or, or generally, as a multi-stage pump.

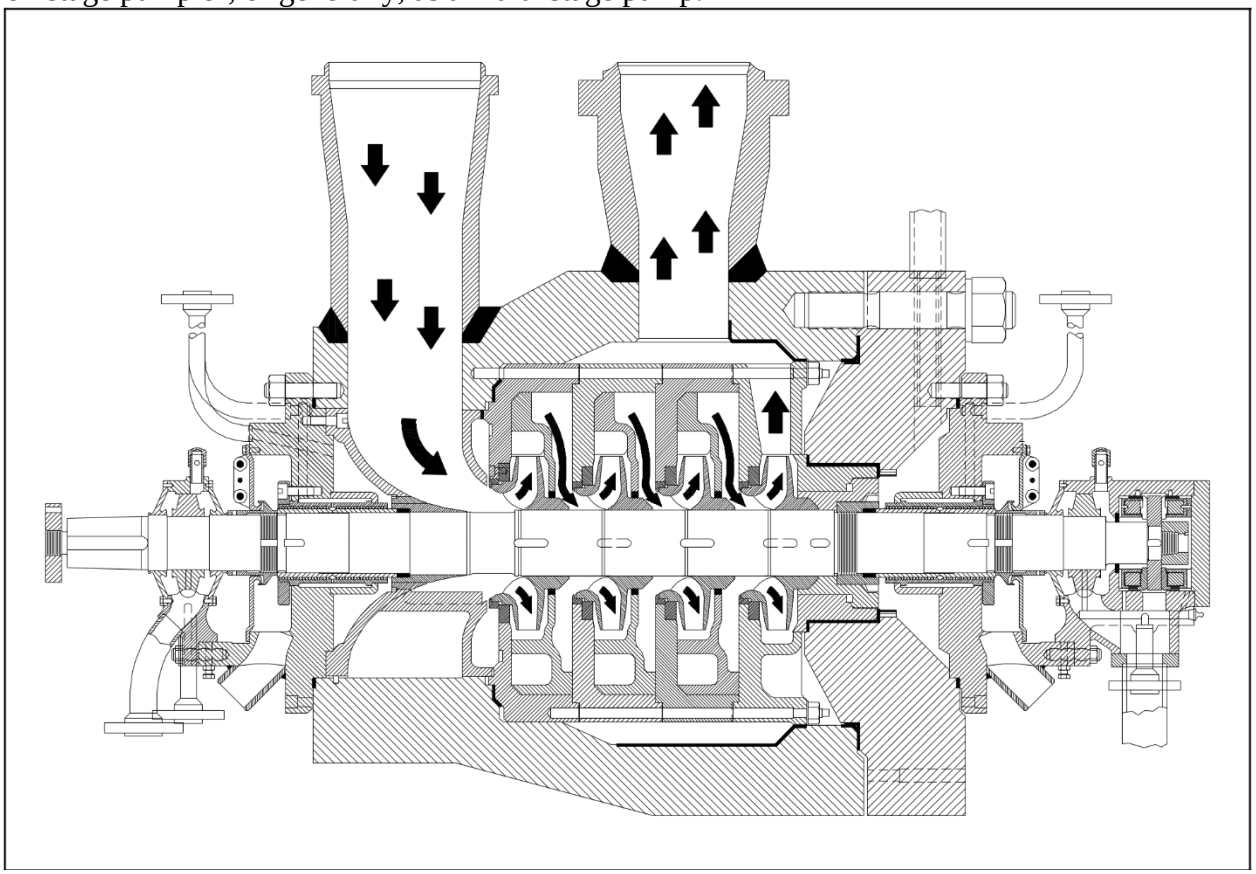


Fig.1.16Multi-stage Centerfugal Pump

Centrifugal Pump Components

Centrifugal pumps vary in design and construction from simple pumps with relatively few parts to extremely complicated pumps with hundreds of individual parts. Some of the most common components found in centrifugal pumps are wearing rings, stuffing boxes, packing, and lantern rings. These components are shown in Figure 10 and described on the following pages.

Wearing Rings

Centrifugal pumps contain rotating impellers within stationary pump casings. To allow the impeller to rotate freely within the pump casing, a small clearance is designed to be maintained between the impeller and the pump casing. To maximize the efficiency of a centrifugal pump, it is necessary to minimize the amount of liquid leaking through this clearance from the high pressure or discharge side of the pump back to the low pressure or suction side.

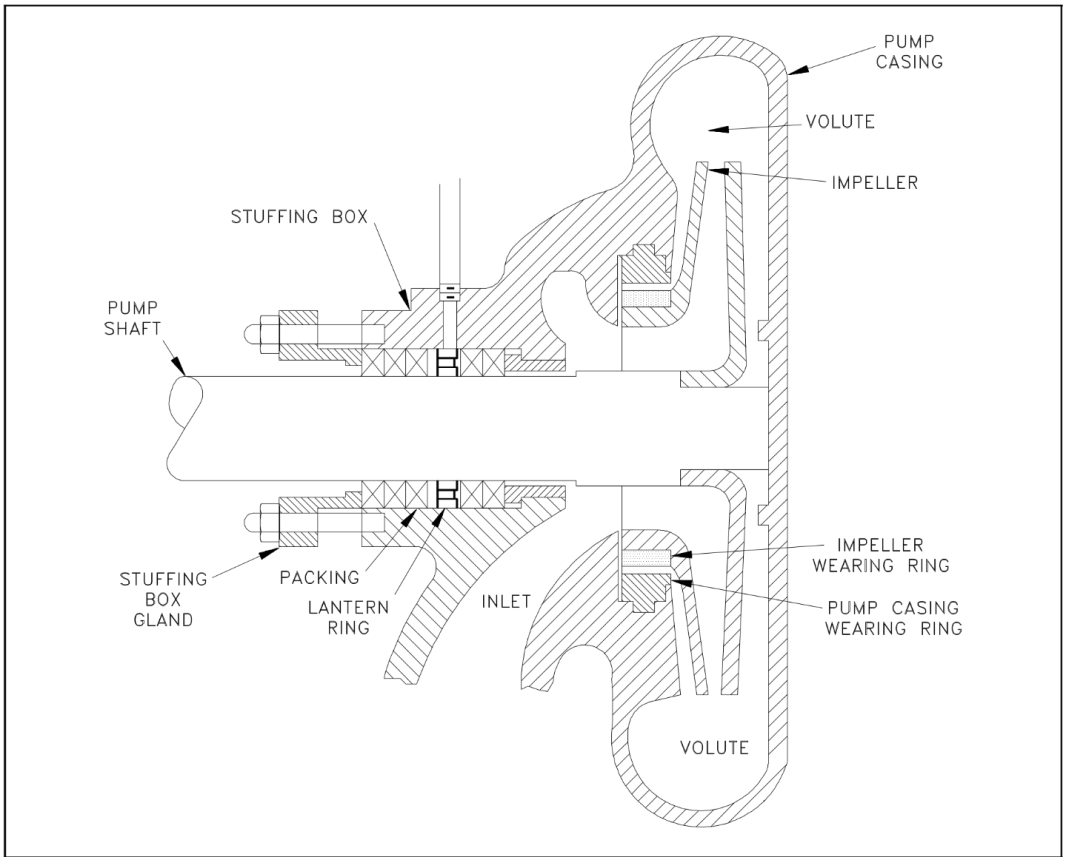


Fig 1.17 Centerfugal Pump Components

Some wear or erosion will occur at the point where the impeller and the pump casing nearly come into contact. This wear is due to the erosion caused by liquid leaking through this tight clearance and other causes. As wear occurs, the clearances become larger and the rate of leakage increases. Eventually, the leakage could become unacceptably large and maintenance would be required on the pump.

To minimize the cost of pump maintenance, many centrifugal pumps are designed with wearing rings. *Wearing rings* are replaceable rings that are attached to the impeller and/or the pump casing to allow a small running clearance between the impeller and the pump casing without causing wear of the actual impeller or pump casing material. These wearing rings are designed to be replaced periodically during the life of a pump and prevent the costlier replacement of the impeller or the casing.

Stuffing Box

In almost all centrifugal pumps, the rotating shaft that drives the impeller penetrates the pressure boundary of the pump casing. It is important that the pump is designed properly to control the amount of liquid that leaks along the shaft at the point that the shaft penetrates the pump casing. There are many different methods of sealing the shaft penetration of the pump casing. Factors considered when choosing a method include the pressure and temperature of the fluid being pumped, the size of the pump, and the chemical and physical characteristics of the fluid being pumped.

One of the simplest types of shaft seal is the stuffing box. The *stuffing box* is a cylindrical space in the pump casing surrounding the shaft. Rings of packing material are placed in this

space. *Packing* is material in the form of rings or strands that is placed in the stuffing box to form a seal to control the rate of leakage along the shaft. The packing rings are held in place by a gland. The gland is, in turn, held in place by studs with adjusting nuts. As the adjusting nuts are tightened, they move the gland in and compress the packing. This axial compression causes the packing to expand radially, forming a tight seal between the rotating shaft and the inside wall of the stuffing box.

The high speed rotation of the shaft generates a significant amount of heat as it rubs against the packing rings. If no lubrication and cooling are provided to the packing, the temperature of the packing increases to the point where damage occurs to the packing, the pump shaft, and possibly nearby pump bearings. Stuffing boxes are normally designed to allow a small amount of controlled leakage along the shaft to provide lubrication and cooling to the packing. The leakage rate can be adjusted by tightening and loosening the packing gland.

Lantern Ring

It is not always possible to use a standard stuffing box to seal the shaft of a centrifugal pump. The pump suction may be under a vacuum so that outward leakage is impossible or the fluid may be too hot to provide adequate cooling of the packing. These conditions require a modification to the standard stuffing box.

One method of adequately cooling the packing under these conditions is to include a lantern ring. A *lantern ring* is a perforated hollow ring located near the center of the packing box that receives relatively cool, clean liquid from either the discharge of the pump or from an external source and distributes the liquid uniformly around the shaft to provide lubrication and cooling. The fluid entering the lantern ring can cool the shaft and packing, lubricate the packing, or seal the joint between the shaft and packing against leakage of air into the pump in the event the pump suction pressure is less than that of the atmosphere.

Mechanical Seals

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. Each of these elements has a highly polished sealing surface. The polished faces of the rotating and stationary elements come into contact with each other to form a seal that prevents leakage along the shaft.

2 Working principle of centrifugal pumps

- Centrifugal pumps have an impeller mounted on a shaft that rotates. The impeller is mounted in the pump housing
- The liquid enters the center, or eye, of the impeller through the suction or pump inlet (suction side) and gains energy in the form of velocity as it passes through the impeller vanes – centrifugal force

- This velocity energy is converted into pressure by the diffuser (the inside shape of the pump housing)

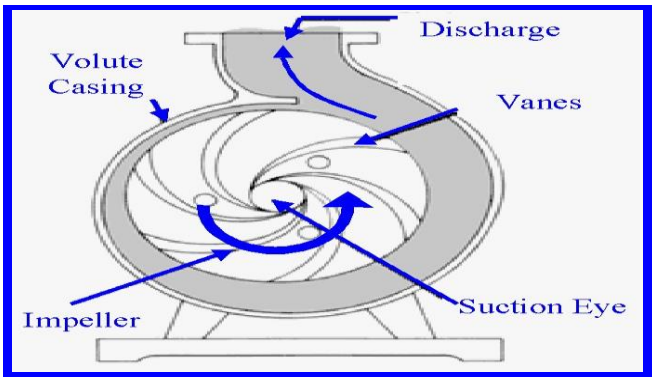


Fig 1.18flow of liquid in centrifugal pump

3. Different types of centrifugal pump

1.3.1 End-suction pumps

End-suction pumps are the most commonly used centrifugal pumps across all industries

- They are called end suction because the inlet, or suction, is at the end and the discharge is at a right angle
- Consist of a single impellor in a casing that also acts as the volute
- Available in close coupled configuration, or long coupled configuration
- Larger sizes are used for irrigation, water supply and industrial process
- Smaller sizes are used for household pressure systems or pool pumps
- If they are fitted with a venture jet (jet pump), they are ideal for household pressure systems when the water tank is below ground level.



Fig 1.19 end suction surface pumps centrifugal pumps

1.3.2 Inline pumps

As the name suggests these pumps have the suction and discharge inline with each other

- Allows for pipeline mounting and was the original concept for inline pumps
- Typically used in heating and air-conditioning applications
- Wet runner or circulator pumps are used in applications where no noise can be tolerated, typically in buildings for heating and cooling systems
- Because the motor bearings (journal) are lubricated by the pumped liquid, the system must be clean
- Without a seal, they are generally leak free




Fig 1.20 Inline pumps

1.3.3 Submersible pumps

- Submersible pumps are used for the removal or transfer of sewage, waste water or storm water
- Designed to operate with the complete pump and motor submerged in the water they are pumping
- The motor on submersible pumps is usually cooled by the liquid they pump and not air cooled like a standard pump
- Usually have the ability to pump solids s the size of the solids will depend on the pump and impeller design

Fig 1.21 Submersible pumps

1.3.4 Multistage pumps

- Multistage pumps are, as the name suggests a number of singles stages of a centrifugal pump, mounted on a common shaft
- This design allows us to efficiently produce high pressure pumps
- These are used for boosting or transferring water where we have large distances or variations in height
- The construction of these pumps is the same as a single stage pump, except there is a diffuser that feeds the water from one impellor to the next
- Multistage pumps are also used for submersible borehole pumps

Fig 1.22Multistage pumps

1.3.5 Jet pumps

Compared to a standard centrifugal pump, a jet pump has two additional components, a jet and a venturi

- The output from the impeller(s) is split and approximately 1/3rd of the water is circulated back to the jet assembly under pressure
- As the water Passes through the jet its velocity is increases but the pressure drops creating a suction effect drawing in entrapped air and water from the suction line

- After passing through the jet the recirculated water enters a tapered venturi where the energy is convert back from velocity to pressure
- These types of pumps are noisy but are very good on a suction lift typically of up to 6 m

Fig 1.23Jet pumps

1.3.6 Shallow well jet pumps

- Shallow well jet pumps are built up around the following components
- Standard centrifugal pump
- Has inbuilt jet/venturi system
- Jet and venturi sizes determine the pumps performance characteristics

Advantages and disadvantages

Advantages – good suction lift capability generally 6m lift
Disadvantages –are generally noisy compared to standard centrifugal pump
-Larger motor required

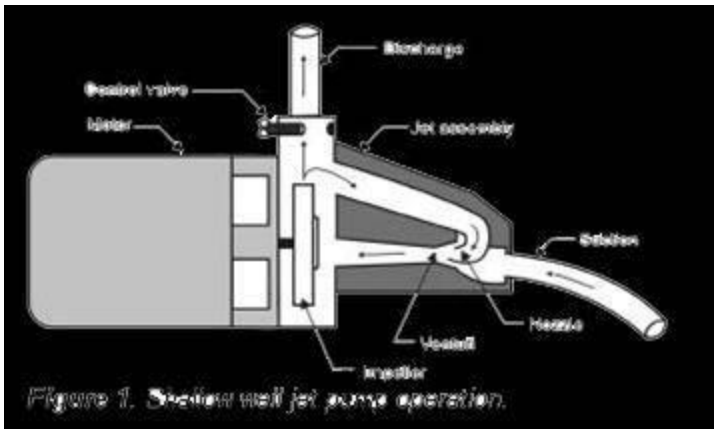


Fig 1.24 Shallow well jet pumps

1.3.7 Deep well ejectors

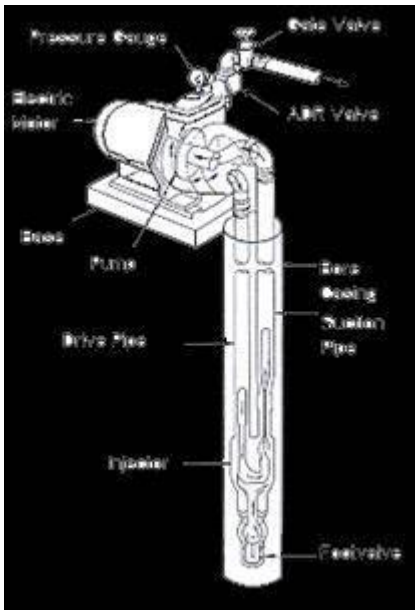
Deep well ejectors recirculate up to 1/3rd of the water from the pump back to the ejector assembly, via a separate pipe (2 pipe system)

Advantages

- Can be installed remote (off set) from water source e.g. away from flood risk
- Pump/motor placed above ground which makes it easy to service

Disadvantages

- Larger motor required, meaning higher running costs



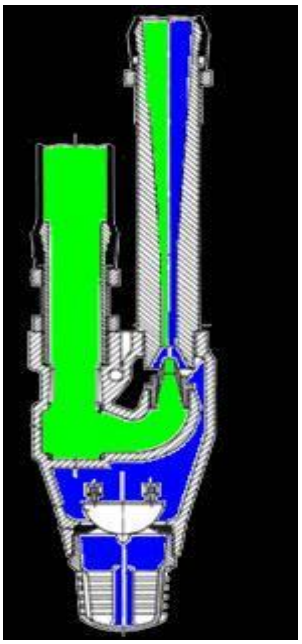


Fig 1.24 Deep well ejectors

1.3.8 Split-case pumps

Split-case pumps are used where water flow requirements are high

Applications

- Water distribution
- Irrigation
- Air conditioning and cooling systems
- Boiler feed

Benefits

- Easy service and maintenance
- Low lifecycle costs
- Large performance area

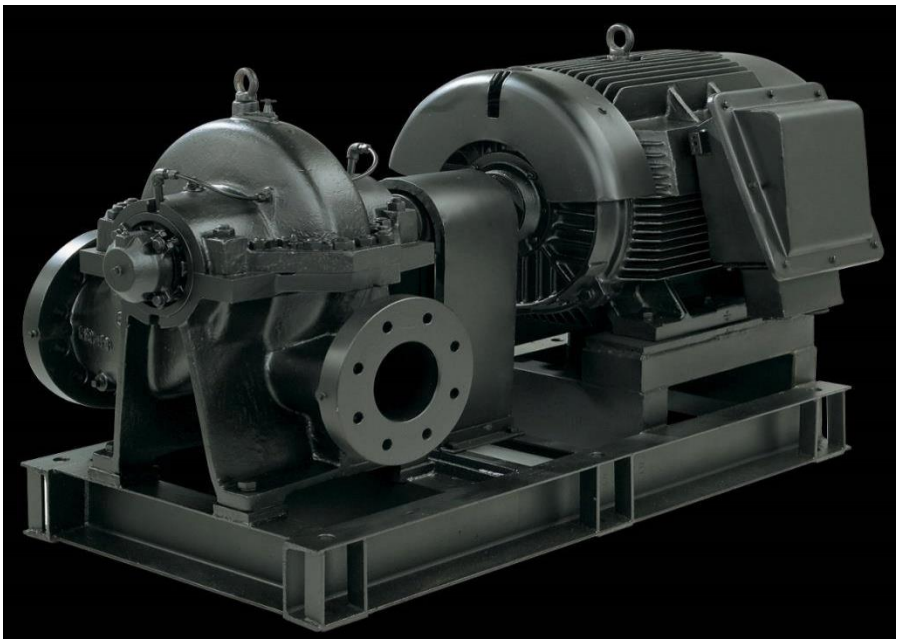


fig 1.25 Split-case pumps

Self-Check -1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. List the two main types of pumps with example. (5 points)
2. Describe working principle of
   - **A.** Centrifugal pumps (5 points)
   - **B.** Positive displacement pumps. (5 points)
3. Differentiate centrifugal pumps according to installation position 5 points)
4. Differentiate between single and multi-stage pumps (5 points)
5. Describe the advantage of split case pump (5 points)

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

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Information Sheet-2	Determining pump station work requirements from standard operating and maintenance procedures

1. Operation and Maintenance Procedures

Operation and maintenance procedures for electromechanical equipment shall be over ruled by the specific manufacturer's manual provided with the specific equipment, and only in the absence of the manufacturers manuals that procedures of this manual can be applied.
Operation and maintenance procedures includes

1.1 Monitoring of Pump Stations
1.2 Pump Station Inspection
1.3 Pump Station Maintenance
1.4 Response Procedures
1.5 Recordkeeping

1.1 Monitoring of Pump Stations

Each station is continuously monitored. Monitoring parameters include, but are not limited to:

- Power status (power failure)
- Wet well status (high well
- Dry well status (where applicable)
- Generator status
- Entry alarm (on the Remote Terminal Unit)

1.2 Pump Station Inspection

In addition to the continuous monitoring, each station is inspected on a regular schedule. The frequency of these inspections is determined on a station-by-station basis, and is based on factors such as age, operating history, size and potential for negative environmental impact.

1.3 Pump Station Maintenance

1.3.1 Preventive Maintenance:

A schedule listing the PM and inspection frequency is maintained for each station. PM activities typically include, but are not limited to the following:
Periodic service and calibration of all instrumentation, such as flow meters, level sensors, alarms, elapsed time meters and telemetry equipment
. Routine inspection and service for all station equipment including:

- Engines and generators
- Motors
- Pumps
- Wet wells
- Impellers
- Seals
- Bearings
- Wear clearances
- Couplings
- Drives
- Air release valves

- Related equipment

1.3.2 Corrective Maintenance:

A procedure for performing corrective maintenance is maintained in each operating section. This procedure includes, but is not limited to:

- Work order writing procedures
- Operator inspection procedures
- Emergency response procedures
- Call in procedures
- Notification procedures if an environmental incident is involved

1.4 Response Procedures

Each operating section has a procedure that includes the proper response for various alarm conditions from the pump stations. Alarm response is determined by personnel availability in the operating section, weather conditions and the characteristics of the station involved. When called for, maintenance personnel are dispatched to the station to evaluate and correct the condition. If the operating section cannot make this response, personnel from another section or from the Central Services section are called in.

1.5 **Recordkeeping**

All maintenance procedure is recorded on the pump station maintenance report form and turned into the maintenance supervisor for review.

Self-Check -2	**Written Test**

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. Write the tasks should be included in maintenance procedures. (5 points)
2. List monitoring points of pump station (5 points)
3. List equipment and components included in preventive maintenance scheduling (5 points)

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

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Information Sheet-3	Selecting and checking equipment and tools

Common tools for pump maintenance

Open end wrenches

Open end wrenches (Figure 3.1) are best suited to square-headed bolts, and usually fit two sizes, one on each end. The ends of this type of wrench are angled so they can be used in close quarters

Fig 3.1 open wrench

Torque wrenches (Figure 3.2) are widely used by machinists and mechanics to provide the correct amount of tightening torque on a screw or nut. A dial reads in English measure (inch-pounds and foot-pounds) or in metric measure (kilogram-centimeters and newton-meters

Fig 3.3 torque Wrench

Filter removal tools
Filter removal tools are used to remove and tighten oil filter and fuel fillters

Fig 3.4 Filter removal

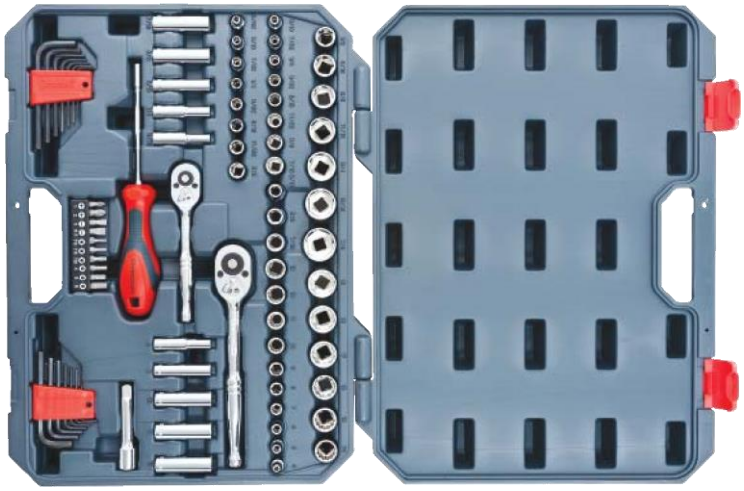


Fig 3.5socket wrenchs

Combination Wrench

The disadvantage of a box-end wrench is the limitation of always having to lift and reposition the wrench in order to continue loosening a fastener. On the other hand, an open-end wrench is much easier to slip off and onto a nut. The combination wrench (**Fig. 3-3**) has the advantage of both a box end and an open-end wrench

Fig 3.6combination wrenches

Pipe wrench: -used to tighten and loosen pipe coupling and also grip round edges to enable other turning/loosening/tightening actions

Figure 3.7. different size pipe wrench

Box-End Wrenches

Exceptionally tight nuts can spread the jaws on even the best open-end wrench. To break the torque on tight nuts a box-end wrench is used.

Fig 3.8 Box-End Wrenches

Allen Wrench

Most headless setscrews are the alien type and must be installed and removed with an Allen wrench. Allen wrenches are six-sided bars in the shape of an L (**Fig. 3-5**). They range in size and fit into a hexagonal recess in the setscrew

Fig.3.9 Allen Wrench /key

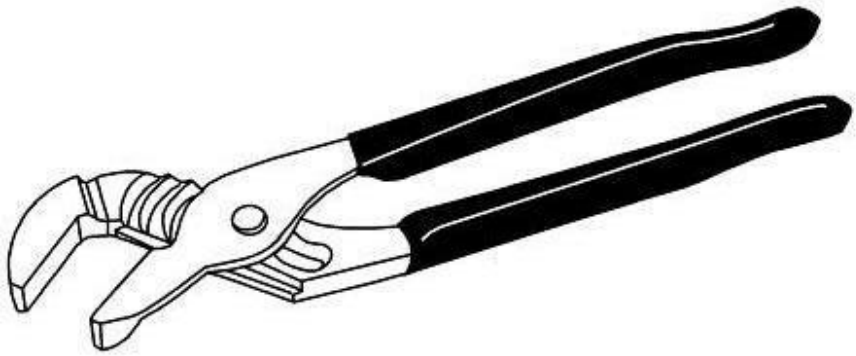
Hummers

Pounding tools include different types and weights of hammers and mallets, each with a very specific use

Fig 3.10 different types of hummers

Interlocking-joint or Pliers

Interlocking-joint pliers are commonly called water pump pliers because they are often used to tighten the packing gland nut around a water pump shaft. These pliers have several curved grooves that make up a series of interlocking joints



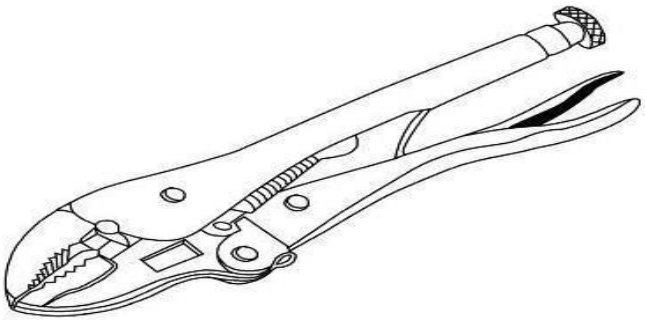


Fig3.11. *Interlocking-joint (water pump) pliers*

Fig3.12 *Vise-Grip pliers*

FEELER GAUGES:

Feeler gauges allow you to measure the distance between very small spaces. If you will be changing spark plugs, adjusting valves, or rebuilding engines you NEED feeler gauges.

Fig 3.13 filler gauge

PLIERS

Pliers come in several shapes and with several types of jaw action. Simple combination or slip joint pliers (Figure B-29) will do most jobs for which you need pliers. The slip joint allows the jaws to expand to grasp a larger size work piece.

A **B** **C**

Fig 3.14 plier(A) Side cutting pliers (B) Diagonal cutters(C) Round nose or wire lopper

Screwdrivers

The screwdriver can be classified by its shape, type of blade, and blade length. It is made for only one purpose, i.e., for loosening or tightening screws or screw head bolts.

Fig 3.15 Screwdrivers

Bearing puller

Bearing pullers are used to extract bearings and shaft sleeves from a shaft

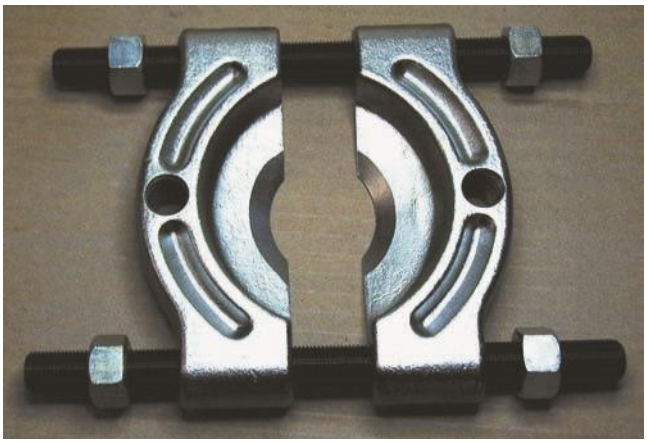


Fig 3.16 bearing puller

Multimeter/clamp meter

Multimeter/clamp meter they are used to measure different electrical parameters such as volt, current, resistance, continuity

Fig 3.17 Multimeter and clamp meter

Megger Tester

Megger is a measuring instrument used for the measurement of insulation resistance of an electrical system.

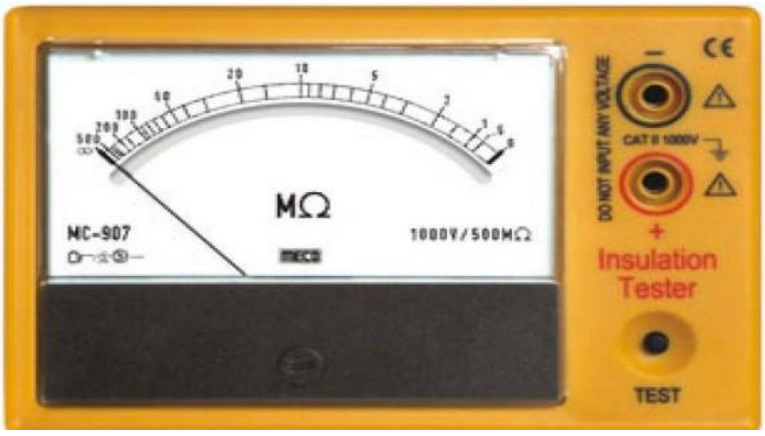


Fig 3.18 megger tester

Self-Check -3	**Written Test**

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. List common hand tools used to maintain pump. (5 points)
2. What is the tool use to
   A. Extract bearing and shaft sleeve (5 points)
   B. Measure wire insulation
   C. Measure small gapes between two parts
3. What is the purpose of
   A. pliers (5 points)
   B. wrenches
   C. Allen key

4 Identify the tools shown on the fig bellow and describe the purpose of the tools.

A

B

C

D

Answer Sheet-3

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

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Information Sheet-4	personal protective equipments and safety

Introduction

Personnel engaged in the operation and maintenance of water supply is dealing with important and dangerous equipment and devices. Important in a sense is that the water supply is life matter to the community and dangerous in that the electrical or mechanical parts can cause death or harm if not operated and maintained safely with knowledge.

Hence, safety measures shall always be considered or safety training should be provided to operators and maintenance personnel.

- Operation and maintenance procedures for electromechanical equipment shall be over ruled by the specific manufacturer's manual provided with the specific equipment, and only in the absence of the manufacturer's manuals that procedures of this manual can be applied.

to start with the safety measures, the utility shall be equipped with:

- A complete first aid kit with alcohol, medicines, bandages, splints, etc.
- A complete set of compulsory tools shall be procured by the utility and be used appropriately.
- one fire extinguisher at the generator house
- never dismantle any component without proper knowledge to inspect
- Never dismantle any piece or part before knowing that an appropriate and working part is available at the utility.

For all maintenance services,

- The operator should ensure that he has adequate illumination,
- Sufficient workspace and secure footing.
- He should not wear loose clothing and jewelry near moving parts.
- He should wear gloves, a safety hat, safety boats and safety goggles as required.

Safety Precautions when using tools

A high percentage of accidents in operation and maintenance are caused by improper use of tools. In this regard, there are several safety measures to be taken, listed as:

- Select the proper tool for the specific job
- Inspect tools and repair or replace damaged or worn once.
- Do not leave tools in places where they may fall and hurt others.
- Do not use tools on moving machinery or equipment
- Allow sufficient clearance and ensure solid footing when preparing to use tools.
- Learn and apply the proper method for using the tool
- Wear eye protection when using impact tools, chipping, wire brushing etc.

Safety precautions when handling electrical equipment:

- It is good practice to wear rubber gloves when starting electric motors
- Operators should be required to stand on rubber mats or wear rubber shoes when handling switch gear.
- During any electrical repair, the power line feeding the equipment to be repaired should be isolated
- High voltage circuits and panels should be repaired only by competent electricians
- Do not touch equipment, cables or any metal that touches, or is in danger of touching, high voltage lines.
- Only approved and inspected extension cords should be used.

- Electric hand tools should always be grounded.
- No electric equipment is to be handled while in contact with water.

Personal Protective Equipment

Figure 4.1 – Typical PPE to be worn by an Operator

Appropriate PPE should always be worn whilst working in and around the generator set. Wear a hard hat, protective glasses, gloves and other protective equipment, as required by generator set location.

When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
Ensure that all protective guards and all covers are secured in place on the engine.
Never put maintenance fluids into glass containers. Glass containers can break.
Use all cleaning solutions with care.
Report all necessary repairs.
Unless other instructions are provided, perform the maintenance under the following conditions:
The engine is stopped. Ensure that the engine cannot be started.
Disconnect the batteries when maintenance is performed or when the electrical system is serviced.
Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

General Hazard Information

Pressurized Air and Water
Pressurized air and/or water (not recommended) can cause debris and/or hot water to be blown out which could result in personal injury.
When pressurized air is used, wear protective clothing, protective shoes and eye protection. Eye protection includes goggles or a protective face shield.

Containing Fluid Spillage

Care must be taken to ensure that fluids are contained during inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Disposal of Waste

Improper disposal of waste can threaten the environment. Potentially harmful fluids should be disposed of according to local regulations. Always use leak proof containers when you drain fluids. Do not pour waste onto the ground, down a drain, or into any source of water.

Fire and Explosion

- All fuels, most lubricants, and some coolant mixtures are flammable. Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire. Fire may cause personal injury and property damage.
- Determine whether the engine will be operated in an environment that allows combustible gases to be drawn into the air inlet system. These gases could cause the engine to overs peed. Personal injury, property damage, or engine damage could result. If the application involves the presence of combustible gases, consult your local Dealer for additional information about suitable protection devices.
- Do not allow any flammable materials to accumulate on the engine. Store fuels and lubricants in properly marked containers away from unauthorized persons. Store oily rags and any flammable materials in protective containers. Do not smoke in areas that are used for storing flammable materials.
- Wiring must be kept in good condition, all electrical wires must be properly routed and securely attached. Check all electrical wires daily, seek appropriate maintenance from your local Dealer for any wires that are loose or frayed, before you operate the engine.
- Arcing or sparking could cause a fire. Secure connections, recommended wiring and properly maintained battery cables will help to prevent arcing or sparking.
- Never check the battery charge by placing a metal object across the terminal posts. Use a voltmeter or a hydrometer.
- The batteries must be kept clean, the covers (if equipped) must be kept on the cells. Use the recommended cables, connections, and battery box covers (where fitted) when the generator set is operated.

Warning

- Do not charge a frozen battery, this may cause an explosion.
- Ensure the generator set room is properly ventilated.
- Keep the room, the floor and the generator set clean. When spills of fuel, oil, battery electrolyte or coolant occur, they should be cleaned up immediately.
- Never store flammable liquids near the engine.
- Store oily rags in covered metal containers**.**
- Do not smoke or allow sparks, flames or other sources of ignition around fuel or batteries. Fuel vapour are explosive. Hydrogen gas generated by charging batteries is also explosive.
- Avoid refilling the fuel tank while the engine is running.
- Do not attempt to operate the generator set with any known leaks in the fuel system.
- Do not use aerosol types of starting aids such as ether. Using these types of items could result in an explosion and personal injury.
- Fire Extinguisher

- Fuels and fumes associated with generator sets can be flammable and potentially explosive. Proper care in handling these materials can dramatically limit the risk of fire or explosion. However, safety dictates that fully charged BC and ABC fire extinguishers are kept on hand. Personnel must be familiar with the operation of the fire extinguisher. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate.

Exhaust Gases

Always start and operate the engine in a well-ventilated area. If the engine is in an enclosed area, vent the engine exhaust to the outside.

Fuels, oils, coolants, lubricants and battery electrolyte used in this generator set are typical of the industry. However, they can be hazardous to personnel if not treated properly. The disposal of fuels, oils, coolants, lubricants, battery electrolyte and batteries should be carried out in accordance with local government laws and regulations.

First aid

If victim is breathing, turn the victim into the recovery position.

If victim is unconscious, perform resuscitation as required:

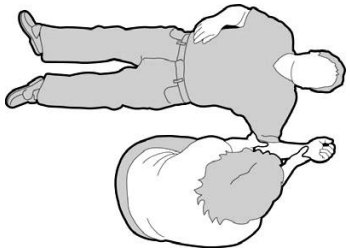
OPEN THE AIRWAY:

Tilt the victim's head back and lift the chin upwards.

Remove objects from the mouth or throat (including false teeth, tobacco or chewing gum).

BREATHING:

Check that the victim is breathing by looking, listening and feeling for the breath.



CIRCULATION:

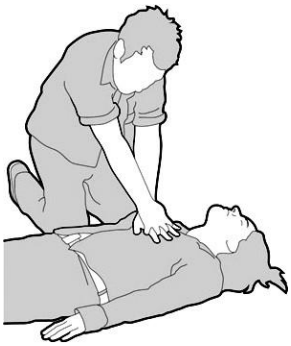
Check for pulse in the victim's neck or wrist.

IF NO BREATHING BUT PULSE IS PRESENT:

- Pinch the victim's nose firmly.
- Take a deep breath and seal your lips around the victim's lips.
- Blow slowly into the mouth watching for the chest to rise. Let the chest fall completely. Give breaths at a rate of 10 per minute.
- If the victim must be left to get help, give 10 breaths first and then return quickly and continue.
- Check for pulse after every 10 breaths.
- When breathing restarts, place the victim into the recovery position described later in this section.

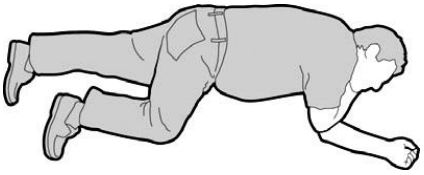
IF NO BREATHING AND NO PULSE:

- Call or telephone for medical help.
- Give two breaths and start chest compression as follows:
- Place heel of hand 2 fingers breadth above ribcage/breastbone junction.
- Place other hand on top and interlock fingers.
- Keeping arms straight, press down 4–5 cm (1.5–2 inch) 30 times at a rate of 100 per minute. There should be equal timing between chest compression and release.
- Repeat cycle (2 breaths, 30 compressions) until medical help takes over.
- If condition improves, confirm pulse and continue with breaths. Check for pulse after every 10 breaths.



- When breathing restarts, place the victim into the recovery position.
- Do not apply pressure over the ribs, lower tip of the victim's breastbone or the abdomen**.**

RECOVERY POSITION:



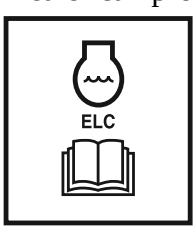
- Turn the victim onto the side.
- Keep the head tilted with the jaw forward to maintain the open airway.
- Make sure the victim cannot roll forwards or backwards.
- Check for breathing and pulse regularly. If either stops, proceed as above.

Warning:

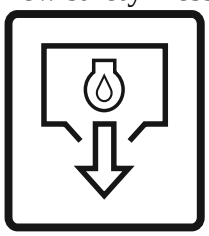
Do not give liquids until victim is conscious.

Hazard Label Legend

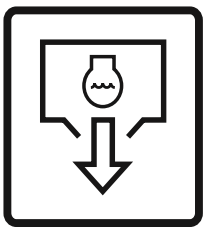
Ensure that all of the safety messages are legible. Clean the safety messages or replace them if the words cannot be read or if the illustrations are not visible. Use a cloth, water and soap to clean the safety messages. Do not use solvents, gasoline, or other harsh chemicals as these could loosen the adhesive that secures the safety messages. Safety messages that are loosened could drop off the engine. Replace any safety message that is damaged or missing. If a safety message is attached to a part of the engine that is replaced, install a new safety message on the replacement part. Your local Dealer can provide new safety messages.



Extended Life Coolant



Oil Drain



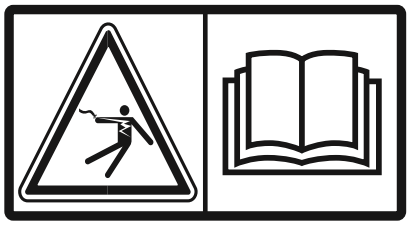
Coolant Drain

Diesel Fuel Fill

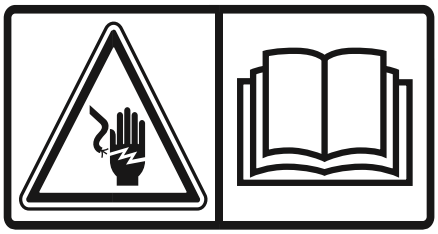
Fuel drain

Hot Fluid Under Pressure

Warning Auto Start



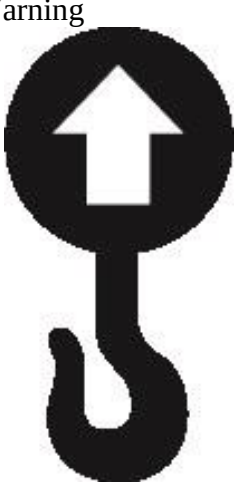
Electric Shock



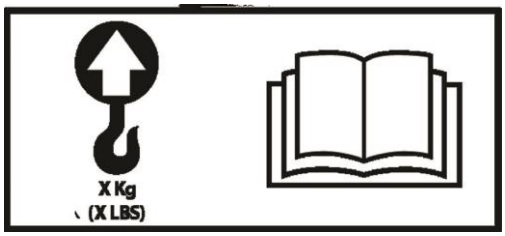
Shock Warning

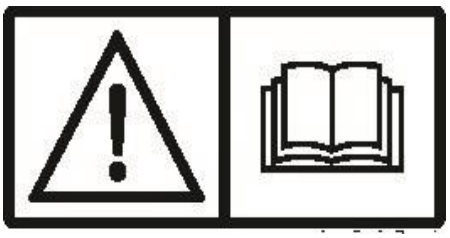
Centre of Gravity

Do Not Touch Warning

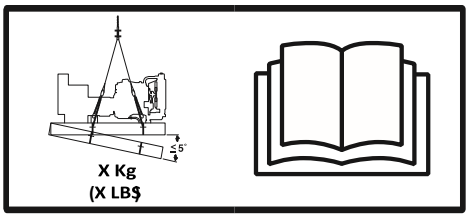


Lift Symbol Single Point Lift is Rated at ’X’ kg Hot Surface Crush Falling Object





Warning - Symbol Read the manual



Four Point Lift is Rated at ’X’ kg

Do Not Lift

Naked Flames

Battery Acid

Explosive Gas

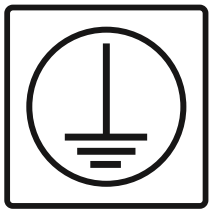
Keep away from children

Shield Eyes

No

Take note of operating

Positive & Negative



Earth

Do NOT Power wash

Self-Check - 4	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. List safety precaution taken when handling tools. (5 points)
2. List safety precaution when working with electric equipment (5 points)
3. List personal protective equipment. (5 points)
4. Which types of fire extinguisher is kept in generator station? Why?

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

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Operation Sheet 1	Prepare for pump station operation and maintenance

Operation title: - Preparing for operation and maintenance

Purpose: - to apply pre operation and maintenance procedure

Tools and equipment: -

- Pen
- Paper
- User and maintenance manual
- tool list record book

Procedure: -

- **Select tools and equipment**
- **Identify monitoring points**
- **Prepare inspection check list**
- **Prepare maintenance log book**
- **prepare operation and maintenance manual**

Instruction Sheet 2	Learning Guide 44: Operating and Monitoring Pump

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
- Carrying out routine security inspections and cleaning duties
- Operating pump station

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
- Carry out routine security inspections and cleaning duties.
- Operate pump station.

Learning Instructions:

15. Read the specific objectives of this Learning Guide.
16. Follow the instructions described in number 3 to 20.
17. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
18. Accomplish the “Self-check 1” in page __.
19. 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-check 1).
20. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
21. Submit your accomplished Self-check. This will form part of your training portfolio.
22. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
23. Accomplish the “Self-check 2” in page __.
24. 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-check 2).
25. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
26. Accomplish the “Self-check 3” in page __.

27. 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-check 3).

If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Activitie

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

1. Pump station components

1.1 Pumping machinery

Pumps and other mechanical equipment, i.e. valves, pipe work, vacuum pumps
Motors, switchgears, cable, transformer and other electrical accessories

1.2 Ancillary Equipment

- Lifting equipment
- Water hammer control device
- Flow meter
- Diesel generating set

1.3 Pumping station

- Sump/intake/well/tube well/bore well
- Pump house
- Screen
- Penstock/gate

water pump: Water pumps are water-lifting devices used to lift water to a height that allows users easy access to water.

Electric Motor: an electric motor is an electrical machinery that convers electrical energy in to mechanical energy

Diesel Generator set: a diesel generator is the combination of a diesel engine and an electric generator (alternator)to generate electric energy

Gate Valve a gate valve is widely used in fluid-handing systems for flow control, Typical gate valves are designed to be fully opened or closed.

Check valve: a check valve is used to control back flow of fluid in a pipe system

Pressure gauge: a pressure gauge is used to indicate the pressure of a fluid in a pipe system

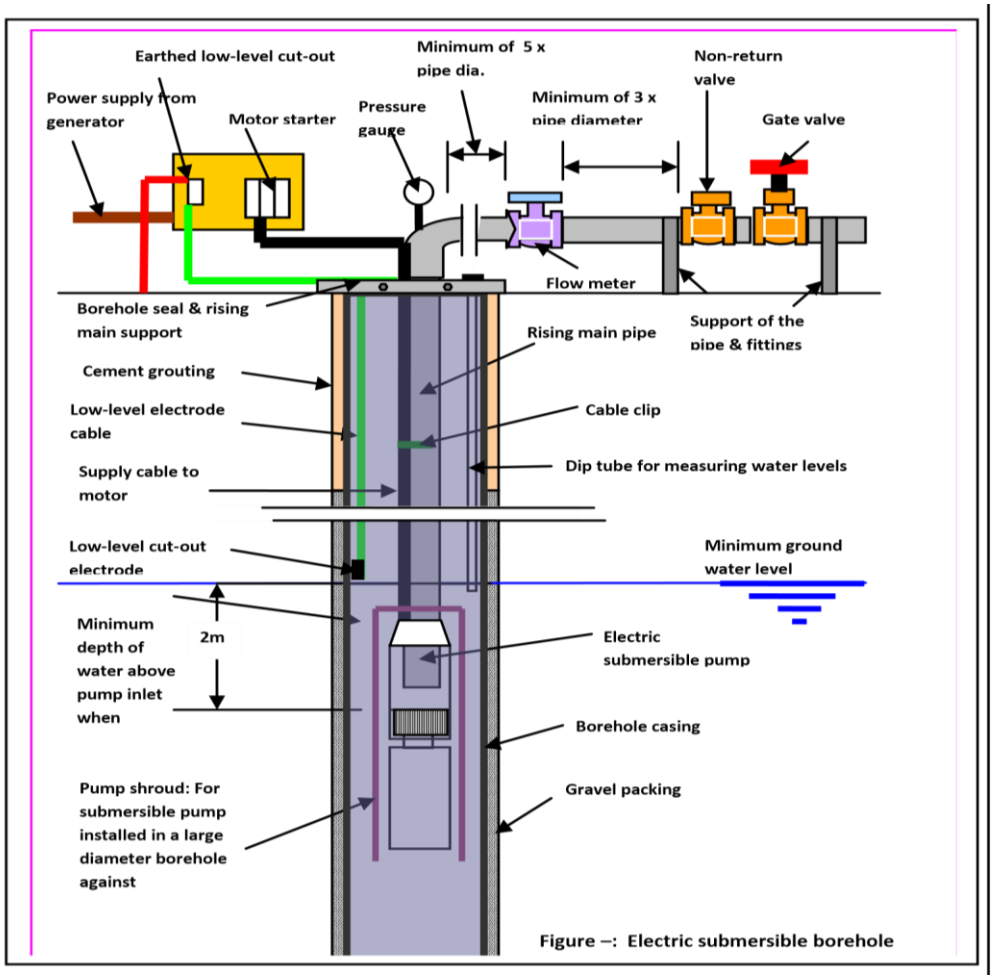


fig.1.1 Deep well pump station components

fig1.2 motor and pump

fig1.3 Control panel

Pressure switch: A pressure switch is used to start the pump when the pressure is low and to stop the pump at higher pressure

Control panel a control panel is used to start and stop pumps and other devises

2. Adjusting pump station components

Control valve adjustment (deep well installation only)

A control valve is required for all deep well installations. At system start-up, this valve will need to be adjusted as described below to assure optimum performance.

1. Install a pressure gauge that reads pressure at the pump case.
2. Open several faucets downstream from the control valve.
3. Loosen control valve locking screw.
4. Rotate the valve to the closed position.
5. Prime the pump (completely fill pump and piping with water)
6. Start pump
7. Open valve slowly until a rapid drop in pressure and flow is noticed, or grinding/ticking noise in the pump is heard. This point is sometimes associated with fluttering of the pressure gauge needle. Begin rotating the valve in the opposite direction (towards closing) until flow and pressure are stabilized and/or the noise is gone.
8. Tighten the locking screw.

PRESSURE SWITCH ADJUSTMENT

The pressure switch is set to start the pump and to stop the pump pressure. The pressure switch should not require adjustment for a typical pump installation. Adjust the switch only if necessary, using the following procedure:

Turn differential nut (See figure and table below) clockwise to increase the pressure difference between cut-in (pump on) and cut-out (pump off) by raising the cut-out pressure

Turn range nut (See figure 7 and table below) clockwise to simultaneously increase both the cut-in and cut-out pressure equally.

NOTE: An optional pressure gage is required when adjusting the pressure switch to determine when the desired pressure settings are achieved. For shallow well installations, a pressure port has been provided in the top of the pump near the discharge for this purpose. For deep well installations, the pressure gauge needs to be located between the control valve and the pressure tank.

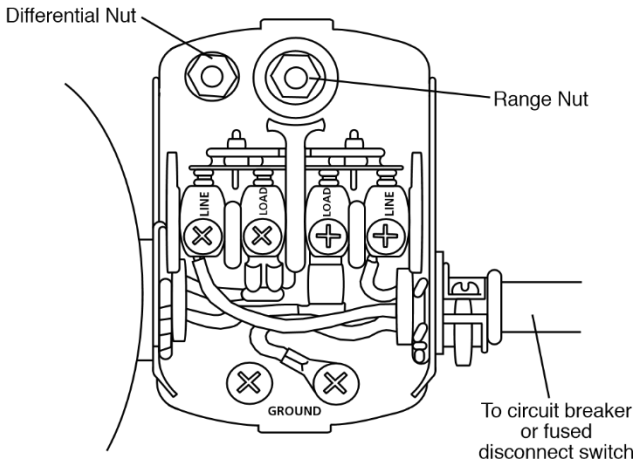


Fig1.4- pressure switch electrical

DO NOT switch on the power before the pump is primed by filling the pump case completely full of water, as damage may occur to the seal and other internal components if run dry.

PRESSURE SWITCH ADJUSTMENT EXAMPLE:

Assumes pressure switch is initially set with a cut-in pressure of 30 psi and cut-out pressure of 50 psi**.**

Starting CUT-IN / CUT-OUT (psi)	Nut Adjustment	Final CUT-IN / CUT-OUT (psi)
30/50	Clockwise turn of Differential Nut	30/60
30/50	Clockwise turn of Range Nut	40/60

NOTICE: Failure to adjust pressure switch cut-in and cut-out settings properly may cause the pump to run continuously or cycle rapidly. continuous operation or
rapid cycling will damage pump and may cause premature failure of other system

Motor-pump Alignment

Motor-Pump alignment is the process of aligning shaft centerlines between a motor and a pump. The motor is the prime mover, transferring power to the pump by the use of a coupling. This is probably the most common configuration of coupled machines in industry.

In this type of alignment, the motor is almost always the moveable machine, and the pump is the stationary machine. In almost all cases, the pump is already piped up with suction and discharge flanges, which means it can move only slightly, if at all.

- Proper shaft alignment is achieved by moving the motor. The motor is shimmed vertically to achieve the proper elevation to align it to the pump, both parallel (offset) and angular.
- The motor is them moved horizontally to achieve proper horizontal placement for aligning the shaft centerlines, both parallel and angular.
- The motor is moved horizontally by the use of jacking bolts, or by the use of pry bars, hammers, or other tools.

Motors are normally easier to move, since the motor is not piped into a process system. A short run of flexible conduit is most often used to run the electrical wiring from a local disconnect, or a rigid conduit, to the motor termination box. This allows for ease of movement of the motor.

Motor-Pump alignment is critical for these reasons:

- It minimizes the forces of misalignment acting upon the bearings and seals of both components.
- It minimizes wear of the coupling.
- It can help reduce energy costs.
- It maximizes the life of the machine components by minimizing wear, increasing time between failures, and reducing vibration.

Motor-Pump alignment should be an important part of any maintenance program.

Fig1.5 Motor-pump Alignment using a dial indicator and a straight edge

Inserting and adjusting stuffing box packing gland

Calculating the correct length of packing rings

There are three different diameters one could use to calculate the length of a

packing ring:

a) the shaft diameter (also called the inner diameter or I.D.)

b) the stuffing-box-housing diameter (outer diameter or O.D.)

c) the "middle "diameter (M.D.)

For the calculation of the length of a packing ring the shaft diameter is too small (resulting in too short a packing ring), the outer diameter is too big (resulting in too long a packing ring); only by using the middle diameter will you be able to calculate the correct length of a packing ring.
How do we find the middle diameter (M.D.)?
There are two ways:

a) M.D. = (I.D. + O.D.) ÷ 2 or
b) M.D. = I.D. + packing cross section

Now it's quite easy to calculate the correct length (L) of a packing ring:

L = M.D. x 3,14 (¶)

IF one would calculate the length of a packing ring as shown above, one would get a ring which is a bit too long at the shaft, just right at the middle and a bit too short on the outside.
BUT due to the construction of a braided packing, each packing ring will get a little bit ***shorter*** when applying pressure on it. And the gland follower will exert quite considerable pressure on the installed packing ring!
Hence, the already existing small gap on the outside of the ring will get bigger and open the packing ring even more at the joint. This will lead to increased leakage or - if one tries to reduce that leakage - to more gland pressure than necessary.

We have said that higher gland pressure (axial pressure) will be partly transformed to radial pressure which will press the packing rings harder against the moving shaft, which in turn will result in higher friction and higher heat build-up, and ultimately to reduced packing life!

The solution is: the packing rings have to be cut a little longer than the result of the above calculation yields!

But there is still more to this:
Ideally we want the leakage on the inside - along the shaft - and not on the outside along the stuffing box-housing. Leakage - or better: the presence of medium - along the shaft ***is*** necessary for lubrication and cooling of the packing rings. Under perfect conditions the shaft will run on a thin film of medium between the shaft and the packing rings, thereby reducing heat build-up and friction to an absolute minimum; which in turn will have a positive effect on packing life.

In order to facilitate the desired leakage along the shaft, and not along the stuffing-box housing, it is necessary that the packing rings shall cling tightly to the stuffing-box housing and not to the shaft.
This can be achieved by cutting the packing rings a few percent longer than the above calculation (L=M.D. x) actually yields!
If a packing ring is a little longer than M.D., then its length will have to be compressed a little during installation. This compression will create stress along the whole circumference of the packing ring, which will press the packing ring outwards against the stuffing-box body.

The axial gland pressure will reduce that force somewhat (see above), but enough of it will remain to achieve the desired effects:

a) the packing rings will NOT open at the joint
b) the packing rings will continually be pressed against the stuffing-box housing, reducing the unwanted leakage there, at the same time facilitating the desired leakage along the shaft.

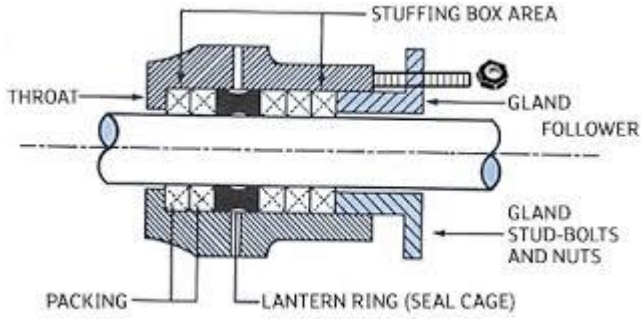


fig 1.6 stuffing box components

Just how many percent should be added to the calculated length depends largely on the style of packing (soft or hard), the shaft diameter and the square section of the packing. It can vary between 2% and 7%!
However, it is absolutely necessary that the person cutting the rings tests the first ring he has cut directly on the shaft, checks if the joint closes properly and if there is just the right amount of "over-length "!

If he finds the ring to be too short (joint not closing), or too long (if he has difficulties fitting the ring), then he has to adjust the length according to his findings before he cuts the rest of the required rings!!

Cutting the packing rings

After having determined the correct length for the packing rings, they will now have to be cut from the spool.

Using a TEADIT packing cutter makes cutting easier and quicker and *reduces* the chance of mistakes.

Winding a PTFE-thread-seal-tape around the packing at the area where the packing is to be cut prevents the ends from fraying.

There are two correct ways of cutting a length of packing:

a) with a 70° angle
b) with a 45° angle

Experience has shown, that a 45° cut yields the best results. But there are two different ways to cut with a 45° angle:

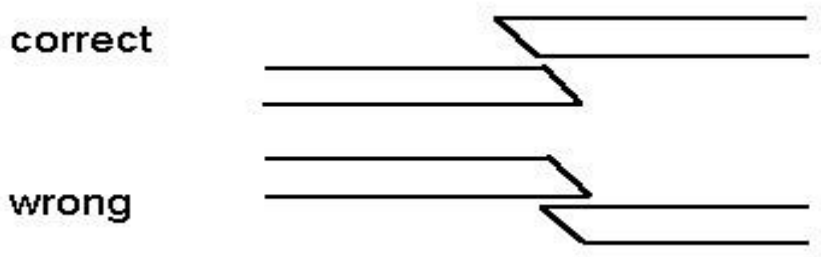
a) 45° axial
b) 45° radial

This shows clearly, that cutting 45° against the shaft (axial) results in the best possible blockage of the flow of the medium!

How to put the packing down on the packing cutter?

This can be done in two ways, of which only one is correct:
The natural curvature (bend) of a packing - which has been wound around a spool for a few weeks or months - should be taken advantage of by bending it that same way around the shaft. IF one puts the packing wrongly (with a 90° twist) onto the packing cutter, then one would still have the correct 45° cut BUT one would have to twist the packing 90° against its natural curvature in order to install it correctly into the stuffing box (see sketch A). The result would be a twisted (distorted) packing ring, which will lead to reduced effectiveness of the packing set.

Inserting the rings into the stuffing box
Insert packing ring with the joint first. Watch out that the correct end is at the top:



Press each ring separately down to the bottom of the stuffing-box (using a semi-sleeve made of wood or similar material)
Stagger joints 360° divided by number of rings, or at least 90°.

Pre-compressing packing set

After all rings are installed, the whole set of rings needs to be compressed *before* start-up of equipment. This serves to settle the packing rings in the stuffing box, get rid of possible hollows or gaps and close the joints properly.

Rotary pumps: for the pre-compression of the packing rings in rotary pumps, no complicated calculations are necessary. There is no leakage to control yet. Just tighten the gland enough to compress the set of rings in a way that all gaps and hollows will be closed.

Piston pumps and valves: tighten the gland with app. 5N/mm^2 (700 PSI). We recommend the use of a torque wrench or a similar device.

After pre-compressing the packing set, loosen the bolts again and retighten with fingers only.

The packing set is now well prepared for start-up.

Start-up procedure and adjustment of leakage

The first few minutes after start-up have a deciding influence on the life of a packing!

Startup pump (open valve(s) beforehand)

The medium will enter the stuffing box through the gap at the bottom and exert an upwards (axial) pressure on the packing rings which are blocking its way. That medium-pressure has basically the same effect on the packing rings as the gland pressure! The axial medium-pressure gets converted to radial pressure which causes the packing rings to press against the stuffing box body and the shaft, thereby automatically reducing the initial leakage!

Naturally, some of the medium will - and should - almost immediately after start-up get past the packing rings and leak out at the gland. Another part of the medium will penetrate the packing rings (the gaps, crevices and fissures which there are between the braids) and make them swell a little. Because the packing rings cannot swell axially, they will do so in the radial direction, which - automatically - reduces leakage even further.

It is important to understand that the medium pressure alone can reduce the leakage to the desired level or even below that (careful, heat build-up), so that the bolts will have to be loosened a little until enough leakage is restored.

However, if after a certain time (the longer one can wait for the packing rings to adjust, the better) the leakage is still too much, the bolts should be carefully tightened to reduce the leakage to an acceptable level.

Too little leakage causes unnecessary friction and heat build-up which can destroy the packing or will at least shorten its life.

Leakage is necessary!

Self-Check 1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

6. List pump station and ancillary components. (5 points)
7. Describe the function of generator set. (5 points)
8. Differentiate between generator and motor. (5 points)
9. Why pump alignment is important? (5 points)
10. What is the purpose of pressure switch?

Note: **Satisfactory rating - 7.5 points and above**
Unsatisfactory - below 7.5 points
You can ask you teacher for the copy of the correct answers.

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

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

1. **Site Security**

Access to the pump station structures as well as all associated equipment and appurtenances shall be restricted

- All ports of entry into pump station structures shall be locked.
- Fencing provided around pump station structures shall be of sufficient height and material to deter entry. Locked gates, a minimum of 12-feet wide, shall be provided in the fence to allow vehicular access by operation and maintenance staff.
- If neither a building nor fencing is provided to protect pump station structures, all access hatches to the wet well, dry well, and other pump station structures should be locked.

The pump station shall be provided with adequate outdoor and indoor lighting to facilitate normal and emergency operation and maintenance activities during daylight and non-daylight hours.

Security inspections

Each pump station facility is maintained in a locked status and is enclosed by a site perimeter security fence and gate that is also locked. Pump access hatches are also locked as well as wet well entry points. Each lift station has a sign in/sign out sheet to record site entry; the sheet is signed by personnel visiting the lift station (date, name, time in/time out), including the reason for the visit.

2. Pump station cleaning

Introduction to cleaning to tools and equipment

A variety of necessary and vital tools and products created and designed in various colors, materials, mechanisms, shapes, sizes and styles to meet a cleaning need and used to clean easily, effectively and efficiently. Cleaning tools are vital to clean especially when your form of employment involves cleaning

It important to clean, sanitize and store equipment properly for us to avoid bacteria from penetrating or accidents. Cleaning and sanitizing the equipment is essential because it helps us to be more secured, far from bacteria and other causes of illnesses.

Maintaining cleaning equipment is important because if your tools are stored incorrectly, the bacteria you're trying to eliminate will grow right on or in them.

The importance of a clean work place.

- Maintaining a clean workplace is vital for employers to reduce their worker compensation claims and keep efficiency high. Essential to safety.
- When employees work in a messy environment, they may not notice all hazards, which increases the risk of an accident.
- Employees are greatly influenced by their workplace environment.

- Attempting workplace creates a good level of comfort in the employees. Keeping a work place clean helps in creating a good environment. There are several essential measures that can help maintain the hygiene of the workplace

2.2. Purpose of cleaning tools and maintenance

To prevent contamination of health supplement products by ensuring that proper cleaning procedure for equipment and accessories in the manufacturing area is in place.

Safety Equipment: Wear gloves, eye protection, and a dust mask when working on tools.

Step 1: Clean Tools. Start by giving your tools a good scrubbing to remove any mud and grit from the blades and handles. ...

Step 2: Remove Rust

Step 3: Sand Tools.

Step 4: Sharpen Tools.

Step 5: Oil Tools

How do you maintain common tools and equipment?
Steps

- Clean your tools. Cleaning the tools regularly is essential to their proper functioning
- Protect electrical cords. Airlines and electrical cords are prone to heavy damage since they are generally in the way of construction vehicles, and foot traffic.
- Lubricate tools
- Inspect tools regularly.
- Store tools with care

2.3. Identify cleaning and maintenance requirements before and after use of tools and equipment

- Understand what is meant by cleaning
- Understand what is meant by maintenance
- Identify all areas that require cleaning, including front of house and back of house
- Identify all items that require cleaning
- Recognize different types of surfaces
- Understand the frequency of cleaning
- Identify and locate all instructions in relation to cleaning
- Understand a job schedule
- Locate task descriptions

- Locate the necessary maintenance and hazard request forms
- Locate all operating instructions for all cleaning equipment
- Read a trading roster and banquet schedule.

2.3.1. Clean industrial work

1. **Assess area to be cleaned**
    - Know the scope of cleaning
    - Know when to clean
    - Understand your role in securing the property.
    - Report unusual activities
    - Recognize different types of soil
    - Know the different cleaning methods.
2. **Select appropriate equipment and chemicals**
    - Locate different types of electrical cleaning equipment and know their uses Locate general cleaning equipment.
3. **Select the protective clothing and equipment to be used**
    - Know which clothing and equipment to wear when performing different cleaning tasks.
4. **Prepare the area**
    - Assess the area
    - Identify any dangers
    - Place any signage and barriers.

2. **Understand the cleaning process**

Know which order to work in.

3. **Dispose of waste**
    - Handle different types of waste
    - Know correct disposal procedures
    - Understand mechanical disposal machines
    - Take precautions when handling waste.

4. **Clean, check and store cleaning equipment and chemicals**
    - Clean all electrical equipment
    - Report any faults
    - Check and clean all protective equipment

- Stack and clean trolley
- Check and refill chemicals.

2.3.2. Clean pump station equipment steps

- Assess suitability of equipment for cleaning
- Identify special cleaning tasks
- Plan for special cleaning tasks
- Plan to use any special equipment
- Select chemicals and cleaning equipment
- Select protective clothing and equipment
- Prepare equipment for cleaning
- Clean hard floors
- Clean soft floors
- Clean wet areas
- Spot carpets stains
- Tidy work area
- Dispose of chemical waste
- Clean equipment
- Replenish chemicals
- Secure the area.

2.3.3. Maintain industrial work areas and equipment

Identify tasks to be undertaken:

- Identify the different classifications of maintenance
- Report maintenance issues
- Identify the different trades

Perform maintenance tasks:

- Perform daily tasks
- Respond promptly to requests
- Use correct equipment
- Understand safety restrictions
- Maintain work equipment
- Select appropriate protective clothing

- Report faults that require additional attention
- Store maintenance equipment
- Understand requisitioning and stock control procedures
- Identify spare parts

Perform administrative tasks:

- Control equipment
- Keep records
- Read maintenance manuals
- Assist in special projects
- Replace major equipment
- Remove old equipment

Liaise with external contractors:

- Know when to use contractors
- Manage contracts

Self-Check 1	Written Test

Instruction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. Discuss the importance of security in pump station (5 points)
2. Describe the requirements pump station security (5 points)
3. Describe the function of generator set. (5 points)
4. Write the purpose of cleaning and maintain tools and equipment (4points)
5. When maintain tools and equipment are cleaned (4 points)

Answer all the questions listed below. Use the Answer sheet provided in the next page:

Instruction 2: - Choose and write the letter of the correct answer on the space provided (2pts each)

1. Which one of the following is not Maintain industrial work areas and equipment?
   A. Identify tasks to be undertaken
   B. Perform administrative tasks
   C. Perform maintenance tasks
   D. Identify power of workers
2. Which one of the following statement is true about maintain common tools and equipment?
   A. Cleaning the tools regularly is essential to their proper functioning
   B. electrical cords are prone to heavy damage
   C. Lubricate tools
   D. Inspect tools regularly and Store tools with care E. all F. none

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

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Information Sheet-3	operating pump station

Operational Procedures in Water Pumping Station

1. Important Points for Operation of the Pumps

Various types of pumps are in use and the specification of O&M schedule provided by manufacturers shall be followed. However, the following points shall be observed while operating the pumps:
Dry running of the pumps should be avoided.

- Centrifugal pumps have to be primed before starting.
- Pumps should be operated only within the recommended range on the head-discharge Characteristics of the pump.
    - If pump is operated at point away from duty point, the pump efficiency normally reduces.
    - Operation near the shut off should be avoided, as the operation near the shut off causes substantial recirculation within the pump, resulting in overheating of water in the casing and consequently, overheating of the pump.
- Voltage during operation of pump-motor set should be within + 10% of rated voltage. Similarly, current should be below the rated current as per name plate on the motor.
- Whether the delivery valve should be opened or closed at the time of starting should be decided by examining shape of the power-discharge characteristic of the pump. Pump of low and medium specific speeds draw lesser power at shut off head and power required increases from shut off to normal operating point. Hence in order to reduce starting load on motor, a pump of low or medium specific speed is started against closed delivery valve. Normally the pumps used in water supply schemes are of low and medium specific speeds. Hence, such pumps need to be started against closed delivery valve. The pumps of high specific speed draw more power at shut off. Such pumps should be started with the delivery valve open.
- The delivery valve should be operated gradually to avoid sudden change in flow velocity which can cause water hammer pressures. It is also necessary to control opening of delivery valve during pipeline - filling period so that the head on the pump is within its operating range to avoid operation on low head and consequent overloading. This is particularly important during charging of the pumping main initially or after shutdown. As head increases the valve shall be gradually opened.
- When the pumps are to be operated in parallel, the pumps should be started and stopped with a time lag between two pumps to restrict change of flow velocity to minimum and to restrict the dip in voltage in incoming feeder. The time lag should be adequate to allow stabilizing the head on the pump, as indicated by a pressure gauge.
- When the pumps are to be operated in series, they should be started and stopped sequentially, but with minimum time lag. Any pump, next in sequence should be started immediately after the delivery valve of the previous pump is even partly opened. Due care should be taken to keep the air vent of the pump next in sequence open, before starting that pump.

- The stuffing box should let a drip of leakage to ensure that no air is passing into the pump and that the packing is getting adequate water for cooling and lubrication. When the stuffing box is grease sealed, adequate refill of the grease should be maintained.
- The running of the duty pumps and the standby should be scheduled so that no pump remains idle for long period and all pumps are in ready-to run condition. Similarly, unequal running should be ensured so that all pumps do not wear equally and become due for overhaul simultaneously. If any undue vibration or noise is noticed, the pump should be stopped immediately and cause for vibration or noise be checked and rectified.
- Bypass valves of all reflux valve, sluice valve and butterfly valve shall be kept in closed position during normal operation of the pumps.

Frequent starting and stopping should be avoided as each start causes overloading of motor, starter, contactor and contacts. Though overloading lasts for a few seconds, it reduces life of the equipment.

2. Additional Points for Operation of the Pumps

3.1 Submersible pumps:

- Correct rotations
- Pump is below static water level before starting, and continues to be below draw down level throughout the operation.

3.2 Surface pumps:

- Correct rotations
- Pump is properly primed before starting if pump suction is negative.

3.3 Vertical turbine pumps

- Pumps properly primed before starting
- Air vent to be fully opened before starting
- Correct rotation of pump.
- Pump should not be operated, if ratchet pins are missing
- Bowl assembly is completely submerged

3. Undesirable Operations

Following undesirable operations should be avoided:

3.1 **Operation at Higher Head**-The pump should never be operated at head higher than maximum recommended. Such operation results in excessive recirculation in the pump, overheating of the water and the pump. Another problem, which arises if pump is operated at a head higher than the recommended maximum head, is that the radial reaction on the pump shaft than the recommended maximum head, is that the radial reaction on the pump shaft increases causing excessive unbalanced forces on the shaft which may cause failure of the pump shaft. As a useful guide, appropriate marking on pressure gauge be made. Such operation is also inefficient as efficiency at higher head is normally low.

3.2 **Operation at Lower Head-**If pump is operated at lower head than recommended minimum head, radial reaction on the pump shaft increases causing excessive unbalanced forces on shaft which may cause failure of the pump shaft. As useful guide, appropriate markings on both pressure gauge and ammeter are made. Such operation is also inefficient as efficiency at lower head is normally low.

3.3 **Operation on Higher Suction Lift**-If pump is operated on higher suction lift than permissible value, pressure at the eye of impeller and suction side falls below vapour

pressure. This results in flashing of water into vapour. These vapour bubbles during passage collapse resulting in cavitation in the pump, pitting on suction side of impeller and casing and excessive vibrations. In addition to mechanical damage due to pitting, discharge of the pump also reduces drastically.

3.4 **Throttled operation**

At times if motor is continuously overloaded, the delivery valve is throttled to increase head on the pump and reduce power drawn from motor. Such operation results in inefficient running as energy is wasted in throttling. In such cases, it is preferable to reduce diameter of impeller which will reduce power drawn from motor. But as the pump operates at low efficiency

3.5 **Operation with Strainer/Foot Valve Clogged**

If the strainer or foot valve is clogged, the friction loss in strainer increases to high magnitude which may result in pressure at the eye of the impeller falling below water vapour pressure, causing cavitation and pitting similar to operation on higher suction lift. The strainers and foot valves should be periodically cleaned particularly during monsoon.

3.6 **Operation of the Pump with Low Submergence**

Minimum submergence above the bell mouth or foot valve is necessary so as to prevent air entry into the suction of the pump which gives rise to vortex phenomenon causing excessive vibration, overloading of bearings, reduction in discharge and efficiency. As a useful guide the lowest permissible water level be marked on water level indicator.

4. STARTING THE PUMPS

Following points should be checked before starting the pump

- Power is available in all 3 phases.
- All connections are properly thimble
- Trip circuit for relays is in healthy state\ Check voltage in all 3 phases
- The voltage in all phases should be almost same and within + 10% of rated voltage, as per permissible voltage variation.
- Check functioning of lubrication system specifically for oil lubricated and clear water lubricated VT pumps and oil lubricated bearings
- Check stuffing box to ensure that it is packed properly.
- Check and ensure that the pump is free to rotate.
- Check overcurrent setting if the pump is not operated for a week or longer period.
- Before starting it shall be ensured that the water level in the sump/intake is above low water level and inflow from the source or preceding pumping station is adequate.

5. Stopping the Pump

Stopping the Pump under Normal Condition

Steps to be followed for stopping a pump of low and medium specific speed are as follows:

1. Close the delivery valve gradually (sudden or fast closing should not be resorted to which can give rise to water hammer pressures).
2. Switch off the motor.
3. Open the air vent in case of V.T. and submersible pump.
4. Stop lubricating oil or clear water supply in case of oil lubricated or clear water lubricated VT pump as applicable

5.1 Stopping after Power Failure/Tripping

If power supply to the pumping station fails or trips, actions stated below should be immediately taken to ensure that the pumps do not restart automatically on resumption of power supply. Though no-volt release or under volt relay is provided in starter and breaker, possibility of its malfunctioning and failure to open the circuit cannot be ruled out. In such eventuality, if the pumps start automatically on resumption of power supply, there will be sudden increase in flow velocity in the pumping main causing sudden rise in pressure due to water hammer which may prove disastrous to the pumping main. Secondly, due to sudden acceleration of flow in the pumping main from no-flow situation, acceleration head will be very high and the pumps shall operate near shut off region during acceleration period which may last for few minutes for long pumping main and cause overheating of the pump. Restarting of all pumps simultaneously shall also cause overloading of electrical system. Hence, precautions are necessary to prevent auto-restarting on resumption on power.

Following procedure should be followed.

- Close all delivery valves on delivery piping of pumps if necessary, manually as actuators cannot be operated due to non-availability of power.
- Check and ensure that all breakers and starters are in open condition i.e. off-position.
- All switches and breakers shall be operated to open i.e. off-position.
- Open air vent in case of V.T. or submersible pump and close lubricating oil or clear water supply in case of oil lubricated or clear water lubricated V.T. pump. Information about power failure should be given to all concerned, particularly to upstream pumping station to stop pumping so as to prevent overflow.

Table 3.1 Starting procedures for water pumps

Step	Item	Description of Activity
1	Connections	Check the integrity of all electrical connections
2	Shaft Rotation (for Turbine pump)	Check the rotation of motor shaft by hand to see if the pump is free. If rotation is not free, correct it by adjusting the top nut. (Rotation should be counter-clockwise when viewed from the top)
3	Lubrication (for Turbine pump)	Lubricate the rubber bearings and gland packing with fresh clean water from the pre-lubrication tank. (Caution – Never use any polluted water as this would contaminate the tube well)
4	Washout valve	Open the washout valve full
5	Discharge Sluice Valve	Close the discharge sluice valve fully. (This reduces power required by the motor at the time of starting)
6	Voltage	Check the voltage in each phase in the panel board by using the phase selector switch. (Caution – Do not switch on the pump if the difference of voltage

		between the phases is more than 10 volts or, the voltage in any phase is less than 380 volts.) If there is no power supply, start standby generator, switch on alternator supply to the pump control panel. Shift power interlocking switch to generator supply position.
7	Starter Relay Setting	Check if the starter relay setting is within the range. (If not, set it correctly)
8	Circuit Breaker & Main Switch	Switch on the circuit breaker and main switch
9	Disinfection	For chlorination by bleaching power solution (i) switch on dosing pump and (ii) check visually that chlorine solution is being pumped, Or, For gas chlorination (i) switch on carrier water booster pump and (ii) adjust rate valve on chlorinator for correct dosing.
10	Starter	Manual Star-Delta Starter – Turn the star-delta starter handle downwards, hold for at least 10-15 seconds then lift up to the second position. (Caution- Do not hold the starter handle downwards more than 15 seconds) Or, for Automatic Starter – Press the start button (usually green button) (Water starts to flow out of the wash out line)
11	Discharge Sluice Valve	Within one minute of starting the pump, gradually open the discharge sluice valve. Water starts to flow into the delivery pipe. (Caution – To prevent overheating of the motor and pump do not keep the discharge sluice valve closed more than one minute while the pump is running)
12	Washout valve	Close the washout valve.
13	Current Flow	Check the normal current consumption. Adjust the discharge valve so that the maximum permissible load current is not exceeded. If normal current consumption cannot be adjusted to or below the permissible load current, stop the pump and inform the office (Caution- Excess opening of the discharge valve may lead to overloading of the motor.)
14	Record	Record pump start time, voltage, ampere, water meter reading (m3), pressure gage reading (kgf/cm2), KWh reading and chlorine dosing rate in the log book

Table 3.2 Supervision during Running of the water Pumps

Step	Item	Description of Activity
1	Operation	Check the operation of the pump is smooth and free from vibration. (Stop the pump if there is any abnormal sound or vibration and inform the office)
2	Pressure	Check the pressure on the delivery pipe. Record in the log book. (Compare with the reading when pump was started. Find reasons if there is large difference in the values. If excessive pressure develops, open the air relief valve or air vent cock to release pressure. If excessive pressure continues, stop the pump and inform the office)
3	Gland packing (for Turbine pump)	Check the gland packing seal is dripping at the required minimum rate. (If leakage is excessive tighten the gland nuts. If excessive leakage continues, stop pump and install new gland packing)
4	Ampere meter	Check ampere meter reading and compare the current with that after pump start.
5	Mains Voltage	Check mains voltage. (Stop pump if voltage in any phase is less than 380 volts or difference of voltage between any two phase is more than 10 volts)
6	Power failure	If there is an interruption of mains power supply, switch off the main switch and the circuit breaker. Note the time of interruption.
7	Record	Record pressure, water meter reading, mains voltage, current and the time of power interruption in the log book.

Table 3.3 Stopping the Pump

Step	Item	Description of Activity
	Discharge Sluice Valve	Close the discharge sluice valve gradually until fully shut. (In case of emergency the pump should be stopped first by switching off)
		Switch off starter, main switch and circuit breaker. (Motor will come smoothly and evenly to a stop).
	Stop disinfection	For Bleaching powder disinfection, switch off dosing pump, or, for gas chlorination system switch off booster pump and close auxiliary valve on the cylinder.
	Record	Record pump stop time, water meter reading (m3) and energy meter reading (KWHr) in the log book.

5 Operating generator set

Pre-Start Checks (applicable to all control systems)

Warning

The following checks detailed below are the only tasks that an operator should undertake.

The following checks should be performed prior to starting the generator set:

5.1 A visual inspection should take only a few minutes and can prevent costly repairs and accidents – For maximum generator set life, visually inspect the generator set before starting. Look for items such as:

- Loose fastenings / fixings, worn belts or loose connections. Repair as necessary.
- The fan and exhaust guards must be at the correct positions and securely fixed. Repair damaged / loose guards or renew missing guards.
- Wipe clean all filler caps before the engine is serviced or fluids are topped up to reduce the chance of any system contamination.
- For any type of leak (coolant, lubricating oil or fuel), clean away the fluid. If a leak is observed, find the source and correct the leak. If a leak is suspected, check the fluid levels frequently until the leak is found and repaired.
- Accumulated grease and / or oil on an engine is a fire hazard. Remove it by steam cleaning or by the use of a high pressure water jet. Avoid high-pressure water on the electronic/electrical components provide suitable protection were possible.
- Ensure that the coolant pipes are fitted correctly and that they are secure. Check for leaks. Check the condition of all pipes for splits or signs of rubbing.

Fluid levels

5.2 Check the engine oil and coolant levels – replenish as necessary (see engine handbook for locations). Ensure fluids used are as recommended within the engine handbook.

Warning:

- **Do not remove the radiator cap or any component of the cooling system while the engine is running and while the coolant is under pressure, because dangerous hot coolant can be discharged, posing a risk of personal injury. Do not add large amounts of cold coolant to a hot system as serious engine damage could result.**

Check the engine oil and coolant levels – replenish as necessary.

Note:

- Diesel engines normally consume lube oil at a rate of 0.25% to 1% of the fuel consumption.

- When adding coolant to the radiator system, always pour slowly to help prevent air from becoming trapped in the engine. Always top up when engine is cold.

Warning:

When filling the fuel tank, do not smoke or use an open flame in the vicinity.

- Check the fuel level – fill as necessary.

Warning:

Before tightening the fan belts, disconnect the battery negative (–) lead to ensure the engine cannot be accidentally started.

- Check the condition and tension of the fan and engine alternator belts – tighten as necessary.
- Check all hoses for loose connections or deterioration – tighten or replace as necessary.
- Check the battery terminals for corrosion – clean as necessary.

Warning:

- *When working with the batteries, do not smoke or use an open flame in the vicinity. Hydrogen gas from batteries is explosive.*
- *Do not short the positive and negative terminals together.*
- Check the battery electrolyte level – fill with distilled water as necessary.
- Check the control panel and the generator set for heavy accumulation of dust and dirt – clean as necessary. These can pose an electrical hazard or give rise to cooling problems.
- Check the air filter restriction indicator, if fitted – replace the filter as necessary.
- Clear the area around the generator set of any insecure items that could inhibit operation or cause injury. Ensure cooling air ventilation screens are clear.
- Visually check the entire generator set for signs of leaks from the fuel system, cooling system or lubrication seals.
- Periodically drain exhaust system condensate traps, if equipped.

Ensure the Alternator Output Circuit Breaker is in the "OFF" (handle down) position.

Table 3.3 Starting Standby Generator and Supervision

Step	Item	Description of Activity
1	Daily Cleaning	Wipe out dust, oil, etc. from the generator surface.
2	Daily Check	While the engine is cold check 1) Engine oil level by dip stick and top up if necessary, 2) Check water level in radiator and top up if necessary, 3) Check fuel level in fuel tank. Add fuel if necessary. Ensure that enough fuel is in storage.
3	Battery	Daily - Clean battery top and terminals Weekly – Check battery electrolyte level, top up with distilled water if necessary
4	Generator supply circuit breaker	Check that the generator supply circuit breaker is in “off” position.
5	Ignition	Turn ignition key to crank the engine. Release key as soon as the engine starts. Allow engine to worm up.
6	Loading	Shift the generator supply circuit breaker to “on” position.
7	Interlock switch	Shift the interlock switch in the panel board to “Generator Supply” position. Deep tube well can be started now.
8	Frequency	After loading adjust frequency if necessary.
9	Operational check	During running check time to time Oil pressure does not fail (will be indicated by red light) Water temperature is normal and does not rise Battery charging rate is appropriate.

Table 3.4 Stopping Standby Generator

Step	Item	Description of Activity
1	Pump	Stop pump
2	Interlock switch	Shift interlock switch to “Public supply” position
3	Generator supply switch	Shift generator supply switch to “off” position and allow generator to run few minutes without load.
4	Cut off fuel supply	Cut off fuel supply to stop the engine.

Self-Check -3	Written Test

Direction I: choose the correct answer to the following questions. Use the Answer sheet provided in the next page:

1. Which of the following is true during operating a pump?

A. The pump is primed before starting

B. The motor should run a voltage with in ±10% the rated voltage

C. The current should read bellow the rated current

D. All

2. Which is the following is correct?

A. Discharge valves should be opened gradually to reduce water hammer

B. A time lag is necessary while starting and stopping pumps in parallel connection system

C. A drop of leakage through stuffing box is permitted to prevent air leaks in to the casing

D. All

E. None

3. One of the following is avoided during pump operation

A. Operation at Higher Head
B. Operation at Lower Head
C. Operation on Higher Suction Lift
D. All

4 Which is correct about a pump start up procedure

A. Close all delivery valves on delivery piping of pumps
B. Check and ensure that all breakers and starters are in open condition
C. All switches and breakers shall be operated to open
D. All

5 One of the following is avoided during pump operation

A. Throttled operation
B. Operation with Strainer/Foot Valve Clogged
C. Operation of the Pump with Low Submergence
D. All

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet for choose questions

1 _____

2 _____

3 _____

4 _____

5 _____

Operation Sheet 1	Adjusting pump motor alignment

Operation title: - Adjusting pump motor alignment
Purpose: - To align pump and motor for smooth operation
Condition for the operation: - Surface water pump set
Tools and equipment: -

- Surface pump
- Electric motor
- Coupling
- Dial indicator
- Straight edge
- Shims
- Spanners
- Hammer
- Pry bar

Procedure: -

1. Shim the motor for vertical alignment
2. Move the motor for horizontal alignment
3. Tight the foundation bolts

Precautions: -

- Wear protective clothing

Quality criteria: - The pump set should run smoothly

Operation Sheet 2	Operating submersible pump

Operation title: - **Operating submersible pump**
Purpose: - pumping water from deep well using submersible pump
Condition for the operation: - deep well pump station or fully organized demonstration site

Equipments: -

- Thee phase supply (generator set or grid electric supply)
- Switch board
- Submersible pump set
- Pressure gauge
- Gate valve
- Pressure relief valve
- Check valve

Tools: - Multimeter, screw driver, plier, spanner
Procedure: -

1. Check the integrity of all electrical connections
2. Close the discharge valve fully
3. Check the voltage in each phase in the panel board by using the phase selector switch or volt meter
4. Check if the starter relay setting is within the range. (If not, set it correctly)
5. Switch on the circuit breaker and main switch
6. Press the start button (usually green button)
7. Gradually open the discharge valve
8. Check the normal current consumption. Adjust the discharge valve so that the maximum permissible load current is not exceeded

Precautions: -

- Wear protective clothing

Quality criteria: -

- The pump set should run smoothly
- There will be no water hammer
- Current reading should be the maximum permissible load current
- The pump should deliver the required discharged at the wright head

Operation Sheet 3	Operating surface water pump

Operation title: - Operating surface water pump
Purpose: - pumping water from deep well using submersible pump
Condition for the operation: - surface water pump station or fully organized demonstration site

Equipments: -

- Thee phase supply (generator set or grid electric supply)
- Switch board
- Surface water pump set
- Pressure gauge
- Gate valve
- Pressure relief valve
- Check valve

Tools: - Multimeter, screw driver, plier, spanner
Procedure: -

1. Check the integrity of all electrical connections
2. Close the discharge valve fully
3. Check the voltage in each phase in the panel board by using the phase selector switch or volt meter
4. Check if the starter relay setting is within the range. (If not, set it correctly)
5. Switch on the circuit breaker and main switch
6. Press the start button (usually green button)
7. Gradually open the discharge valve
8. Check the direction of rotation of the shaft
9. Check the operation of the pump is smooth and free from vibration
10. Check the gland packing seal is dripping at the required minimum rate
11. Check the normal current consumption. Adjust the discharge valve so that the maximum permissible load current is not exceeded
12. Record pressure, water meter reading, mains voltage, current

Precautions: -

- Wear protective clothing

Quality criteria: -

- The pump set should run smoothly
- There will be no water hammer
- Current reading should be the maximum permissible load current
- The pump should deliver the required discharged at the wright head
- Check the gland packing seal is dripping at the required minimum rate

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary equipments, tools and materials you are required to perform the following tasks within3hr hour

Task 1. Start generator set

Task 2. Start surface/submersible pump

Task 3. Stop the pump

Task 4. Stop the generator

Equipments: -

- Thee phase supply (generator set or grid electric supply)
- Switch board
- Surface water pump set
- Pressure gauge
- Gate valve
- Pressure relief valve
- Check valve

Tools: - Multimeter, screw driver, plier, spanner

Instruction Sheet 3	**Learning Guide 45:** Maintain pump stations

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

1. Inspecting pump station components and identifying maintenance
2. Scheduling Minor maintenance tasks, ordering appropriate materials and conducting maintenance tasks
3. 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 –

- Inspect pump station components and identify maintenance needs.
- Schedule minor maintenance tasks, order appropriate materials and conduct maintenance tasks.
- Pump station faults are identified and reported and minor repairs carried out

Learning Instructions:

28. Read the specific objectives of this Learning Guide.
29. Follow the instructions described in number 3 to 20.
30. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
31. Accomplish the “Self-check 1” in page __.
32. 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-check 1).
33. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
34. Submit your accomplished Self-check. This will form part of your training portfolio.
35. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
36. Accomplish the “Self-check 2” in page __.
37. 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-check 2).

38. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
39. Accomplish the “Self-check 3” in page __.
40. 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-check 3).
41. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Activities.

Information Sheet-1	Inspecting pump station components and identifying maintenance need

1. Inspecting pump station components and identifying maintenance needs

Physical Inspection

A physical inspection is vital to an O&M program. Without it, a maintenance program cannot be implemented in a systematic way since system problems cannot be quantified. Elements of a physical inspection program include visual and equipment-based techniques that use established industry methods of system evaluation. Physical inspections should be performed on a regularly scheduled basis as a part of the preventive maintenance program.

The purpose of conducting inspections is to:

- Identify what is in the system (inventory).
- Identify the location of the system's components.
- Determine the condition of the components (assessment).

1.1 Inspecting pump and identifying maintenance needs

Maintenance inspections

A maintenance schedule includes these types of inspections:

- Routine maintenance
- Routine inspections
- Three-month inspections
- Annual inspections

Shorten the inspection intervals appropriately if the pumped fluid is abrasive or corrosive or if the environment is classified as potentially explosive.

Routine maintenance

Perform these tasks whenever you perform routine maintenance:

- Lubricate the bearings.
- Inspect the seal.
- Adjust packing gland

Routine inspections

Perform these tasks whenever you check the pump during routine inspections:

- Check the level and condition of the oil through the sight glass on the bearing frame.
- Check for unusual noise, vibration, and bearing temperatures.
- Check the pump and piping for leaks.
- Analyze the vibration.
- Inspect the discharge pressure.
- Inspect the temperature.

- Check the seal chamber and stuffing box for leaks.
- Ensure that there are no leaks from the mechanical seal.
- Adjust or replace the packing in the stuffing box if you notice excessive leaking.

Three-month inspections

Perform these tasks every three months:

- Check that the foundation bolts are tight.
- Check the packing if the pump has been left idle, and replace as required.
- Change the oil every three months (2000 operating hours) at minimum.
- Check the shaft alignment, and realign as required.
- Check the pump and motor hold down bolts for proper tightness.

Annual inspections

- Perform these inspections one time each year:
- Check the pump capacity.
- Check the pump pressure.
- Check the pump power.

If the pump performance does not satisfy your process requirements, and the process requirements have not changed, then perform these steps:

1. Disassemble the pump.
2. Inspect it.
3. Replace worn parts.
4. Assembling

1.2 Inspecting motor and identifying maintenance needs

Daily Inspection

- Clean external surface of motor.
- Examine earth connections and motor leads.
- Check temperature of motor and check whether overheated. The permissible maximum temperature is above the level which can be comfortably felt by hand. Hence temperature observation should be taken with RTD or thermometer. (Note: In order to avoid opening up motors, a good practice is to observe the stator temperature under normal working conditions. Any increase not accounted for, by seasonal increase in ambient temperature, should be suspected).
- In case of oil ring lubricated bearing.
    - Examine bearings to check whether oil rings are working.
    - Note bearing temperature.
    - Add oil if necessary.
    - Check for any abnormal Bearing noise.

Monthly Inspection

- Check belt tension. In case where this is excessive it should immediately be reduced.
- Blow dust from the motor.
- Examine oil in oil lubricated bearing for contamination by dust, grit, etc. (this can be judged from the color of the oil).

- Check functioning and connections of anti-condensation heater (space heater).
- Check insulation resistance by mongering.

Quarterly Inspection

- Clean oil lubricated bearings and replenishes fresh oil. If bearings are grease lubricated, the condition of the grease should be checked and replaced/replenished to correct the condition of the grease should be checked and replaced/replenished to correct quantity. An
- Anti-friction bearing should have its housing so packed with grease that the void space in the bearing housing should be between one third to half. A fully packed housing will overheat the bearing and will result in reduction of life of the bearing.
- Wipe brush holders and check contact faces of brushes of slip-ring motors. If contact face is not smooth or is irregular, file it for proper and full contact over slip rings.
- Check insulation resistance of the motor.
- Check tightness of cable gland, lug and connecting bolts.
- Check and tighten foundation bolts and holding down bolts between motor and frame.
- Check vibration level with instrument if available; otherwise by observation.

Half Yearly Inspection

- Clean winding of motor, bake and varnish if necessary.
- In case of slip ring motors, check slip-rings for grooving or unusual wear, and polish with smooth polish paper if necessary.

Annual Inspections and Maintenance

- Clean and flush bearings with kerosene and examine for flaws developed, if any, e.g. wear and scratches. Check end-play. Immediately after cleaning, the bearings should be coated with oil or grease to prevent ingress of dirt or moisture.
- Clean bearing housing and examine for flaws, e.g. wear, grooving etc. Change oil or grease in bearing housing.
- Blow out dust from windings of motors thoroughly with clean dry air. Make sure that the pressure is not so high as to damage the insulation
- Clean and varnish dirty and oily windings. Re-varnish motors subjected to severe operating and environmental conditions e.g., operation in dust-laden environment, polluted atmosphere etc.
- Check condition of stator, stamping, insulation, terminal box, fan etc.
- Check insulation resistance to earth and between phases of motors windings, control gear and wiring.
- Check air gaps.
- Check resistance of earth connections

1.3 Generator set inspection

When the generator set is running, operators need to be alert for mechanical problems that could create unsafe or hazardous conditions. Following are several areas that should be inspected frequently to maintain safe and reliable operation

- **Exhaust system:** With the generator set operating, inspect the entire exhaust system including the exhaust manifold, muffler and exhaust pipe. Check for leaks at all connections, welds, gaskets and

joints, and make sure that the exhaust pipes are not heating surrounding areas excessively. Repair any leaks immediately.

- **Fuel system:** With the generator set operating, inspect the fuel supply lines, return lines, filters and fittings for cracks or abrasions. Make sure the lines are not rubbing against anything that could cause an eventual breakage. Repair any leaks or alter line routing to eliminate wear immediately.
- **DC electrical system:** Check the terminals on the starting batteries for clean and tight connections. Loose or corroded connections create resistance which can hinder starting.

1.4 Engine:

Monitor fluid levels, oil pressure and coolant temperatures frequently. Most engine problems give an early warning. Look and listen for changes in engine performance, sound, or appearance that will indicate that service or repair is needed. Be alert for misfires, vibration, excessive exhaust smoke, loss of power or increases in oil or fuel consumption

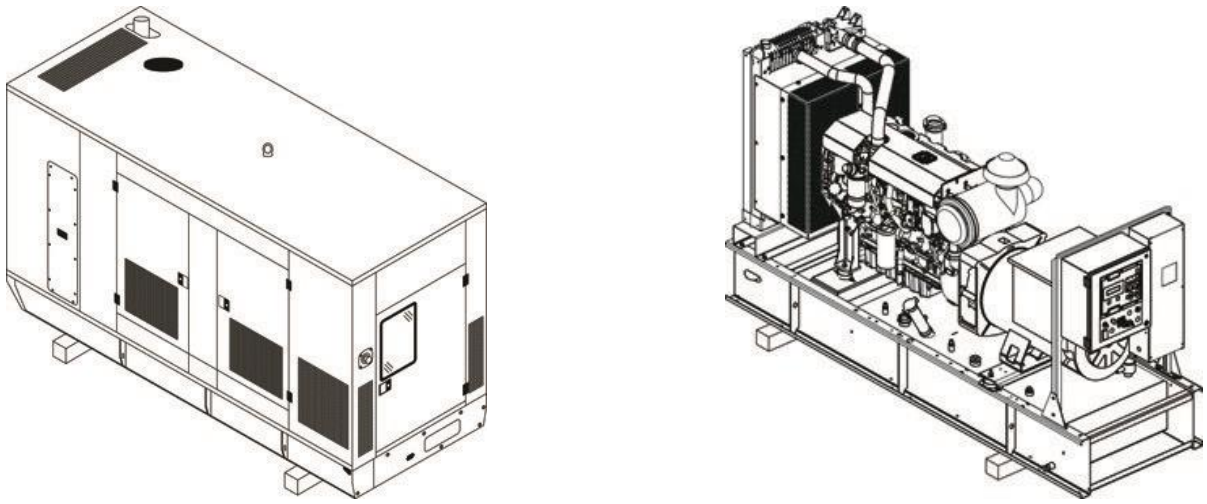

Fig 1.1 Generator Set

GENERATOR DAILY INPECTION CHECK LIST

Generator ID No: _____ Period: _____

	MON	TUE	WED	THU	FRI	SAT	SUN
	Staff doing inspection should initial each box as he/she finds that item is functioning OK.						
Running Hours (check the hourly guage and enter amount)							
Generator is clean and							
Shed is clean and in							
Fuel tank at least 50%							
Fuel leaks?							
Fuel cap on?							
Motor Oil level is okay?							
Motor Oil condition?							
Radiator, no leaks?							
Radiator coolant level							
Battery connections							
Battery water level ok?							
Battery Charger is							
No Leaks (look							
Exhaust system is							
Auto-start is working?							
All Tools and Wrenches							

Self-Check 1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. Describe the purpose of inspection. (5 points)
2. List routine maintenances taken on pump. (5 points)
3. List routine inspection taken on pump operation. (5 points)
4. List routine inspection taken on motors (5 points)
5. List routine inspection taken on motors

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

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Information Sheet-2	Scheduling Minor maintenance tasks, ordering appropriate materials and conducting maintenance tasks

Introduction

Lack of preventive and timely maintenance or poor maintenance can cause undue wear and tear of fast moving parts, and premature failure of the equipment.

The shortcomings in maintenance can also result in increase in hydraulic and power losses and low efficiency. Inefficient running of the pump increases burden of power cost. Importance of preventive maintenance, therefore, need not be overstressed.

Appropriate maintenance schedule and procedure need to be prescribed for all electrical and mechanical equipment based on manufacturers' recommendations, characteristics of the equipment, site and environment conditions i.e. temperature, humidity, dust condition, etc.

The preventive maintenance schedule shall detail the maintenance to be carried out at regular intervals i.e. daily, monthly, quarterly, half yearly, annually etc. or operation hours. The schedule shall also include inspections and tests to be performed at appropriate interval or periodicity.

Scheduling minor maintenance tasks

A guidance to manager and field for scheduling and performing preventative maintenance activities on the pump stations is required. The guidance includes detailed PM activities to insure that all scheduled PM activities are routinely completed.

When preparing a maintenance schedule, always refer the manufacturers' manual for each piece of equipment. Equipment manuals will recommend maintenance frequency and also specifications as to the types of fuel, lubricant or oil needed to ensure peak performance and maximum life expectancy. Be sure to follow these recommendations in strict accordance so that you will get the most out of your valuable equipment

- Identification of all systems and equipment where PM is required.
- Itemization of required PM tasks for each item of equipment.
- Instruction in equipment, tools, and materials required to complete PM work.
- Training necessary to complete PM activities.

PM Scheduling

Preventative maintenance activities are scheduled according to the equipment manufacturer procedures or Maintenance Manager and Maintenance Planner.

Electrical PM Activities

UWS-MS has implemented both preventative maintenance and predictive maintenance procedures for pump station electrical systems and equipment. Electrical preventative maintenance is performed as a normal part of the scheduled pump station inspections. In general, electrical preventive maintenance performed by the operation staff includes the following:

- Inspection of electrical service.
- Control panel inspection, cleaning and testing.
- Motor Inspection to check connections, vibration, temperature and lubrication.

The electrical PM schedule is listed on **Table 2-1**.

Pump Station Electrical Maintenance Schedule

Equipment	Activity	Activity Type	Required Frequency
Lighting	Check operation	GI	W
	Clean	PM	A
Control Panels	Check operation	GI	W
	Inspect motor starters	PM	M
	Inspect overloads	PM	M
	Inspect alternating relay	PM	M
	Inspect phase monitor	PM	M
Motors	Check condition	GI	A
	Inspect electrical connections	GI	A
	Check current & voltage by phase	GI	A
	Check alternating pump operation	GI	M
Gauges/Meters	Check operation	GI	W
	Recalibrate	PM	A
Level Control - Floats	Clean floats	PM	M
	Test level alarm	PM	M
	Check SSO alarm	PM	M

GI = General Inspection
PM = Preventative Maintenance
W = Weekly
M = Monthly A = Annually

Generator

The generator set: -

- Manufactured and mounted only to produce electrical energy. Any other use, even if occasional is forbidden.
- Shall not be wetted, sprinkled water or other liquid on the generating set.
- Should not be touched with moist parts of the body wear, the protection devices and garment required by the rule.
- Children and non-experienced persons should not be allowed to operate.

If generator is on operation: -

- Check if there are any abnormal noises, vibration, over temperature, oil leakage, etc.
- Check the transfer of power to the pump.
- All windows, doors and ventilations shall be opened in order to circulate fresh air in the room. These opening shall produce 20% of the room area and the room area shall be $10m^2$. However, this shall be considered during construction.
- The exhaust gases shall be released out of the room by means of strong sealed steel tubes; cast iron connecting pieces may also be used. The end of the pipe has to be at least 1.50m from windows, doors, opening parts or ventilation air intakes, and at least 3m high from the floor.
- The pipes inside the room have to be wrapped round with non-conducive materials since their external surface temperature has to be less than 100^{oc}.
- The material for heat insulation and protection has to be fireproof or class1 fire reaction fuels.
- Should never come in contact with water during operation. The non-observance of this rule brings the danger of electric shocks and damage to the generating set itself.
  Every procedure of putting generating set in to service, starting, working and shut down of generator recommended by the manufacturer shall be respected.
  Note: Switch on the generator before turning on the switch on the switchboard.

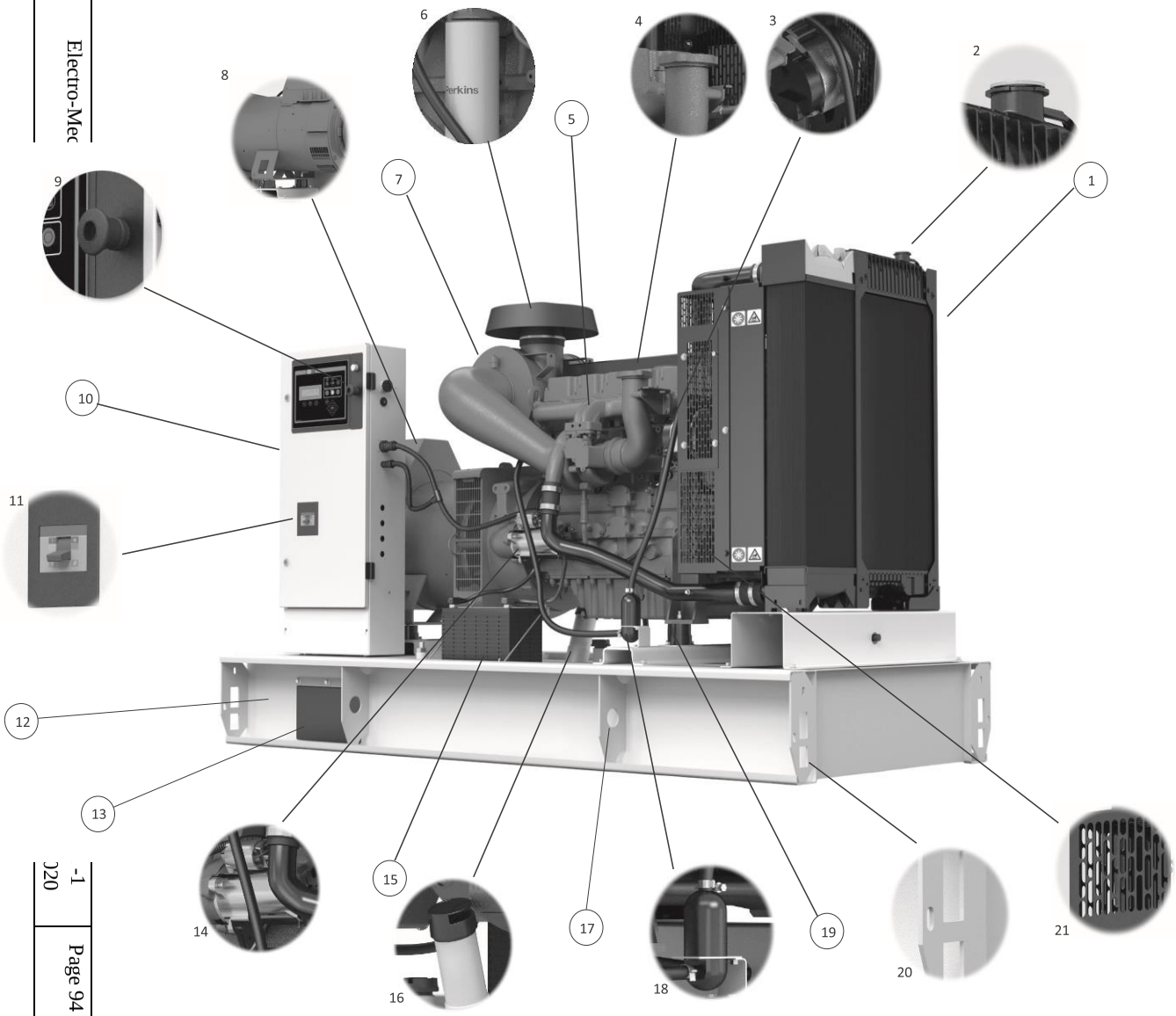
  Lubrication and maintenance of the equipment should also be effected regularly as directed in the manufacturers' instruction. Dates of lubrication and dates on which wear parts are replaced should be recorded in the logbook.
  The routine maintenance of the generator can be summarized as follows: (The list is not exclusive, refer in priority to relevant manufacturers manual)
- Check oil level once a weak.
- Check belt tension every month.
- Clean air suction filter every month.
- Clean and remove dust on equipment bodies every month (especially for motor cooling).
- Check bolt tightening every month; tighten if required.
- Refer to lubrication schedule every month.

Record of operations and observations

A log book should be maintained to record the hourly observations, which should cover the following items

- Timings when the pumps are started, operated and stopped during 24 hours,
- Voltage in all three phases,
- Current drawn by each pump-motor set and total current drawn at the installation,
- Frequency (50Hz),
- Readings of vacuum and pressure gauges,
- Motor winding temperature,
- Bearing temperature for pump and motor,
- Water level in intake/sump,
- Flow meter reading,
- Daily PF over 24 hours' duration,

Any specific problem or event in the pumping installation or pumping system e.g. burst in pipeline, tripping or fault, power failure



1. Radiator
2. RadiatorFill
3. BatteryChargingAlternator
4. Exhaust
5. Turbo
6. OilFilter*
7. AirFilter
8. Alternator
9. EmergencyStopPushbutton
10. ControlPanel
11. CircuitBreaker
12. BaseFrame
13. CableEntry
14. StarterMotor
15. Battery
16. FuelFill*
17. LiftingPoints
18. JacketWaterHeater
19. AntiVibrationMounts*
20. DragPoints
21. FanGuards

*=Oppositeside

I **Generatorsetscontainmoving partsandhotsurfaces.Wearthe appropraitePPEasrequired.**

Figure3.2–TypicalGeneratorsetDescription(thismaydifferfromtheGeneratorsetyouhavereceived)

Table 2.2: Operation and Maintenance scheduling of Generators

Task Description	Frequency	Tools/Equipment and Materials	Manpower requirement
Greasing	Daily	Tools, paper and pen	operator
Clean air filter or replace as required, check leakage of fuel and oil, tighten bolts and nuts, check the filter of water radiator for water cooled sets, check the power of the battery and speed of the engine	After every 125 hours of working	Tools, paper and pen	operator
To clean the fuel nozzles if the exhaust air is not normal, check the belts and correct is loosen, clean fuel filter if the fuel is not clean, clean oil filter or replace	After every 250 hours of working	tools	operator
Replace fuel filter	After 500 hours of working	tools	operator
Remove the carbon content in the engine if its power is low, or after 2000 hours of working, correct the valve clearance space, clean the head of the cylinder, and its heat removal part, check the belts and replace is required	After 1000 hours of working	Tools	Technician
Service the engine wholly	After 5 years or 15,000hours of working	Tools and engine removing equipments	Company which has complete workshop

Mechanical PM Activities

Preventive Maintenance of mechanical systems and equipment is also performed as part of the normal pump station inspection activities. Mechanical PM instructions are developed based on equipment manufacturer O&M recommendations and procedures, any specialized requirements of individual pump stations, and knowledge of the O&M staff. Pump station mechanical PM includes the following (where applicable):

- Pulling and inspecting submersible pumps
- Pump drive maintenance and coupling alignment
- Pump testing

- Valve exercising and maintenance

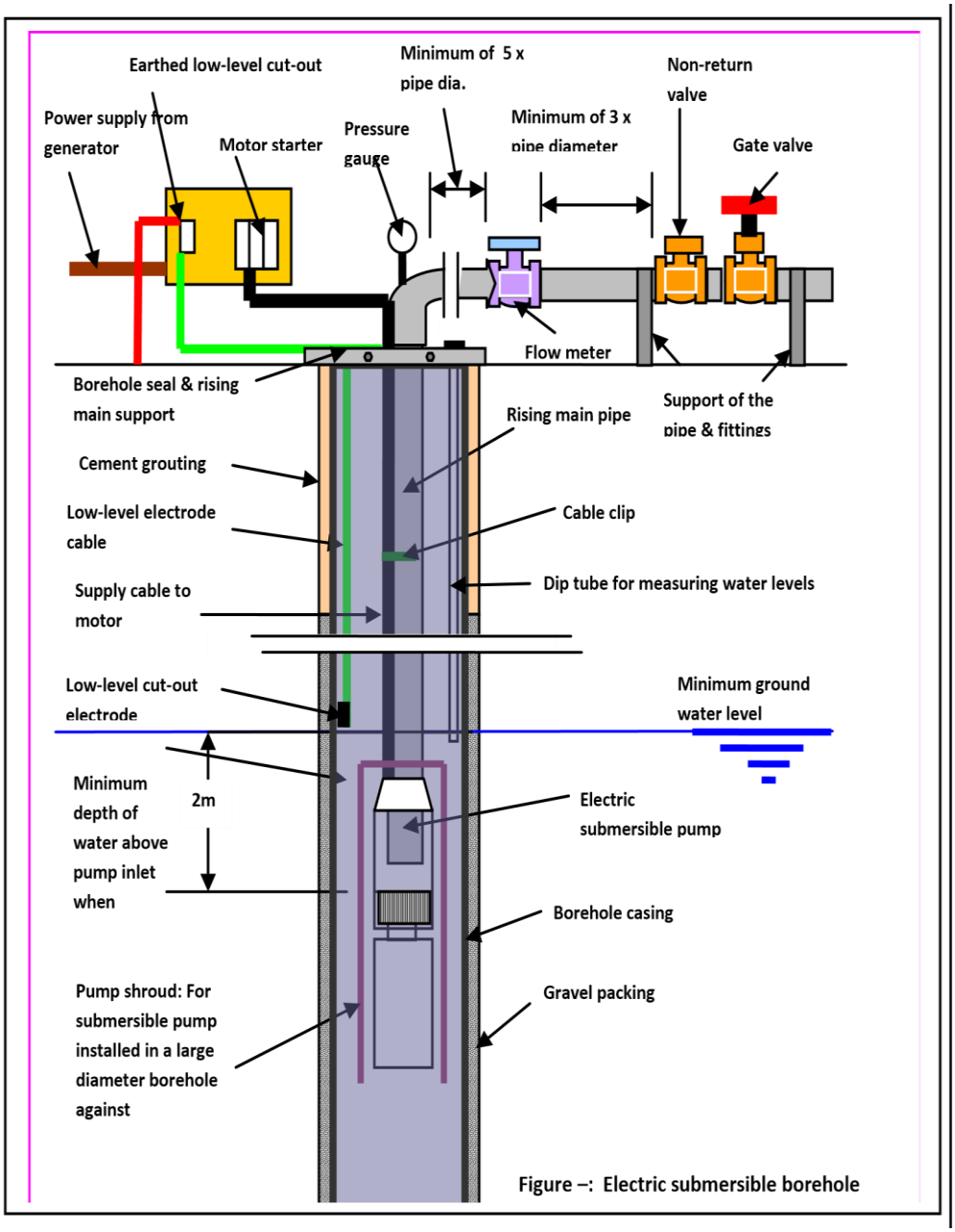


Fig2.2 Submersible pump station

Scheduling pump maintenance

Fig 1.1 Submersible pump station components

Fig2.3 surface water pump station

Table 1-2 lists scheduled mechanical maintenance activities.

Table 2.3
Pump Station Mechanical Maintenance Schedule

Equipment	Activity	Activity Type	Required Frequency
Level Control - Bubbler	Check operation	GI	W
	Clean out airline	GI	W
	Replace airline	PM	A
Couplings	Check operation	GI	W
	Lubricate	PM	M

Pumps - Submersible	Pull and inspect	PM	A
Pumps - Dry Pit	Check operation	GI	W
	Check packing/seals	GI	W
	Lubricate bearings	GI	M
	Inspect belt/sheaves	GI	M
	Check for vibration	PM	M
Valves - Air Relief	Inspect and clean	GI	M
Valves - Check	Lift arm to check operation	GI	M
Valves - Isolation	Exercise	PM	M
	Inspect packing seals	PM	A

GI = General Inspection
PM = Preventative Maintenance
W = Weekly
M = Monthly A = Annually

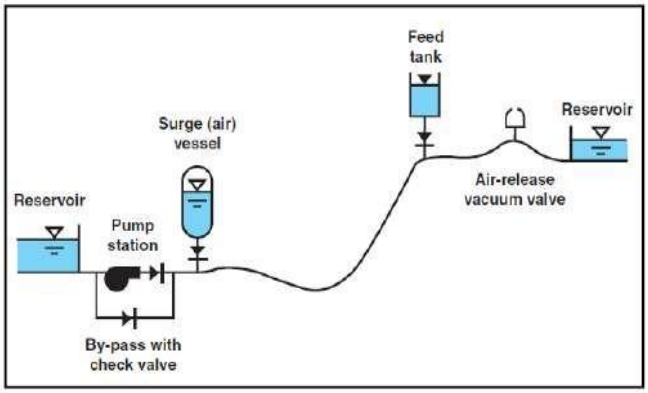


Fig2.4 water hammer control devices

Maintenance Schedule for Water Hammer Control Devices

Maintenance requirements of water hammer devices depend on type of water hammer control device, nature of its functioning, water quality etc.

The training facilitator explains the different types of water hammer control devices used in water pumping installations as follows:

- Surge tank
- One-way surge tank
- Air vessel (air chamber)
- Zero velocity valve and air cushion valve. □
- Surge anticipation valve (surge suppressor)
- Pressure relief valve.

Discuss the general guidelines for maintenance of different types of water hammer control devices as follows:

Surge Tank

- **Quarterly**: Water level gauge or sight tube provided shall be inspected, any jam rectified, all cocks and sight tube flushed and cleaned.
- **Yearly**: The tank shall be drained and cleaned once in a year or earlier if frequency of ingress of foreign matter is high.

Maintenance Schedule for Valves at Pumping Station

The following five types of valves in pumping installation exist, these are:

1. Foot valve,
2. Sluice valve,
3. Knife gate valve,
4. Non-Return (Reflux) valve, and
5. Butterfly valve.

Maintenance of valves at pumping station is presented in Table 1.3.

Table 2.4: Maintenance of Valves at Pumping Stations

Type of Valves	Maintenance Tasks
Foot Valve	☞ Clean foot valve once in 1-3 months depending on ingress of floating matters, ☞ Clean flap of the foot valve once in 2 months to ensure leak proof operation, ☞ Inspect the valve thoroughly once in a year. Check for leakage through foot valve after priming and observing level in volute casing.
Sluice and Knife Gate Valves	☞ Check gland packing of the valve at least once in a month. It should be ensured that pickings' inside the stuffing box are in good trim and impregnated with grease. ☞ It may be necessary to change the packing as often as necessary to ensure that the leakage is within limit. ☞ Grease should be applied to reduction gears and grease lubricated thrust bearing once in three months. ☞ Check tight closure of the valve once in 3 months. ☞ A valve normally kept open or closed should be operated once every three months to full travel of gate and any jamming developed due to long disuse shall be freed. ☞ Inspect the valve thoroughly for flaws in guide channel, guide lugs, spindle, spindle nut, stuffing box etc. once in a year.

	☞ Important **DON'T** for valve is that it should never be operated with oversize hand wheel or cap or spanner as this practice may result in rounding of square top and hand wheel or cap or spanner may eventually slip. ☞ An important **DON'T** for valve is that it should never be operated under throttled i.e. partially open condition, since such operation may result in undue chatter, wear and failure of valve spindle.
Non-Return (Reflux) Valve	☞ Check proper operation of hinged door and tight closure under no-flow condition once in 3 months. ☞ The valve shall be thoroughly inspected annually. Particular attention should be paid to hinges and pins and soundness of hinged door. ☞ Condition of dampening arrangement should be thoroughly examined once in year and necessary maintenance and rectification as per manufactures' instructions shall be carried out. ☞ In case of dampening arrangement, check for oil leakage and replace oil once in a year.
Butterfly Valve	☞ Check seal ring and tight shut-off once in 3 months. ☞ Lubricate gearing arrangement and bearing once in 3 months. ☞ Inspect the valve thoroughly including complete operations once in a year. ☞ Change oil or grease in gearing arrangement once in a year.
General	☞ Operate bypass valve wherever provided once in 3 months. ☞ Flange adapter/dismantling joint provided with valve shall be loosened and retightened once in 6 months to avoid sticking.

Maintenance Schedule for L.T. Starters, Breakers and Panel

Note: Circuit diagram of starter/breaker should be posted on door of switch gear and additional copy should be kept on record. Table 1.4 below is presented the maintenance tasks for Starter, breaker and panel in the pumping station.

Table 2.5: Maintenance Activities of L.T Starter, Breaker and Panel

Maintenance Duration	Activities
Daily	☞ Clean the external surface. ☞ Check for any spark or leakage current. ☞ Check for overheating
Monthly	☞ Blow the dust and clean internal components in the panel, breaker and starter. ☞ Check and tighten all connections of cable, wires, jumpers and bus-bars. All carbon deposits shall be cleaned. ☞ Check relay setting
Quarterly	☞ Check all connections as per circuit diagram. ☞ Check fixed and moving contacts and clean with smooth polish paper, if necessary. ☞ Check oil level and condition of oil in oil tank. Replace the oil if carbon deposit in suspension is observed or color is black. ☞ Check insulation resistance. ☞ Check condition of insulators.
Yearly	☞ Check and carry out servicing of all components, thoroughly clean and reassemble. ☞ Calibrate voltmeter, ammeter, frequency meter etc.

Physical PM Activities

This PM component addresses maintenance requirements for physical facilities, consisting of piping, vaults, covers, buildings, other structures, and site improvements. The physical maintenance activities are listed on Table 2.6.

Table 2.6
Pump Station Physical Maintenance Schedule

Item	Activity	Activity Type	Required Frequency
Building	Check locks	GI	M
	Check lights	GI	M
	Check doors	GI	M
	Perform housekeeping	GI	M

	Perform grounds maintenance	GI	M
	Inspect walls, roofs, and slabs	GI	A
	Check paint condition	GI	A
	Inspect windows	GI	A
	Inspect fencing	GI	A
Wet Well	Inspect covers and locking device	GI	W
	Check for cracks or settling	PM	A

GI = General Inspection
PM = Preventative Maintenance
W = Weekly
M = Monthly A = Annually

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Maintenance of Pumping Station

Maintenance of pumping station such as screens, gate, sump / intake / well and pump house including civil works as described below:

Screens

1. Screen should be cleaned at a frequency depending on ingress load of floating matters. The frequency in monsoon season shall be more than that in fair season. However, cleaning frequency should be at least once in a week, or, if head loss in screen exceeds 0.20 m.
2. Care should be taken to remove and dump the screening far away from the pump house.
3. Lubricate wheels and axle of wheel burrows.
4. The screen, catch tray and screen handling arrangement shall be thoroughly inspected once in six months and any item broken, eroded, corroded shall be rectified.

Sump/Intake Well

- All foreign floating matters in the sump/intake shall be manually removed at least once in a month and shall be disposed off away from pump house,
- De-silting of intake/sump shall be carried out once in year preferably after wet season. Care should be taken to dump the removed silt away from pump house.
- It is generally observed that reptiles like snakes, fish, etc. enter intake particularly in wet season. The intake should be disinfected.
- The sump/intake should be fully dewatered and inspected once in a year.
- It is advisable to undertake leakage test of sump once in a year. For this purpose, the sump shall be filled to FSL and drop in water level for reasonably long duration (2-3 hours) should be observed. If leakage is beyond limit, rectification work shall be taken.

Pump House

- The pump house should be cleaned daily. Good housekeeping and cleanliness are necessary for pleasant environment,
- Entire pump house, superstructure and sub-structure shall be adequately illuminated and well ventilated. Poor lighting, stale air etc. create unpleasant environment and have an adverse effect on will of the staff to work,
- Wooden flooring and masonry stone grating wherever damaged should be repaired on priority,
- It is observed that at many places, roof leaks badly and at times the leakage water drips on the panel/motor which is dangerous and can cause short circuit and electric accidents. All such leakages should be rectified on priority.
- All facilities in sub-structure i.e. stair case, floors, walkways etc. should be cleaned daily.
- Painting of civil works should be carried out at least once in two years.

Recommended preventive maintenance checks for centrifugal pumps and drives

Interval	Routines	Date/Initial
Daily	Check pump for noisy bearings and cavitation.	
Daily	Check bearing oil for water and discoloration.	
Daily	Feel all bearings for temperature.	
Daily	Inspect bearings and oil rings through filling ports. Wipe bearing covers clean.	
Daily	Check oil leaks at the gaskets.	
Daily	Self-flush pumps - Hand check the flush line temperature to determine flow through the line. External flush pumps - Determine if flow indicator and needle valve adjustment are functioning properly.	
Daily	Determine if the mechanical seal conditions are normal.	
Daily	Check any water cooling for effective operation. Hand test differential across coolers, jackets and exchangers. Disassemble and clean as required.	
Daily	Check the operability of the heat tracing.	
Daily	Determine if steam leakage at packing and glands is normal.	
Daily	Check for leaks at pressure casing and gaskets. Determine if steam traps are operating properly no continuous blow & water in casing or drain.	
Monthly	Add oil to the bearing reservoirs, if required.	
Monthly	Clean oiler bulbs and level windows as required.	
Monthly	Make sure that the oil level is the correct distance from the shaft centerline. Adjust if necessary.	
Monthly	Clean out debris from bearing brackets. Drain hole must be open.	
Monthly	Change oil in hydraulic governors.	
Monthly	Determine if hydraulic governor heater is working.	
Monthly	Check for proper oil level & leaks at hydraulic governor. Check for oil leaks at lines, fittings & power piston.	
Monthly	Replace guards (repair if required).	
Monthly	Determine if pump unit requires general cleaning by others.	
6 Months	Machines not running - Standby service: Overfill bearing housing to bottom of the shaft and rotate several turns by hand to coat the shaft and the bearing with oil.	
6 Months	Apply a light coat of rust preventive product to expose machined surfaces to prevent rust and corrosion.	
6 Months	Clean & oil governor linkage & valve stems.	

6 Months	Exercise overspeed trip & valve steam linkage on turbines not running.	
Yearly	Thoroughly inspect disc coupling for signs of wear & cracks in laminations. Tighten bolts.	
Yearly	Using a dial indicator, check the coupling alignment with the equipment coupled. Use special coupling indicator clamps where possible. Ensure that thermal growth allowance is correct.	
Yearly	Using an indicator clamped on the coupling, depress and lift on each coupling and note the dial indicator change. Determine if the deflection is normal for this machine. Refer to OEM manual.	
Yearly	Using an indicator, check axial float of the pump & the driver shaft in similar manner.	
Yearly	Remove turbine sentinel valve. Shop test & adjust to proper setting.	
Yearly	Inspect trip and throttle valve stems and their linkages for wear. Check over-speed mechanism for wear. (Turbine must be down).	
Yearly	Remove mechanical the governor cover & inspect fly ball seat, spring, bearing & plunger for wear.	

VIII−3

Yearly	Uncouple from pump & over speed turbine. Ensure that trip valve will stop turbine with steam supply valve (throttle valve) fully open. Compare tripping speed with previous records. Adjust trip mechanism & repeat procedure. Follow manufacturer s instructions when making adjustments.	
Yearly	Where the process will allow it, test run the turbine coupled to the pump. When not possible, run the turbine uncoupled. With a tachometer − verify proper governor operation & control. Determine if hand (booster) valves are completely closed when required to carry load. This influences steam economy.	
Seasonal		
Fall & Summer	Do a seasonal oil change out, if required by OEM lubrication guide.	
Fall	Where cooling water is decommissioned, ensure that no water remains in the jackets, coolers and piping.	
Fall	Inspect for damaged or missing insulation	
Fall	Reestablish steam flow or electrical tracing continuity.	

Self-Check 1	Written Test

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page

1. Describe tasks included in Pump Station Electrical Maintenance Schedule (5 points)
2. Describe tasks included in Operation and Maintenance scheduling of Generators. (5 points)
3. Why pump alignment is important? (5 points)
4. For the equipments and activities listed in the table below decide the frequency of each activity

	Equipment	Activity	Activity	frequency
A	**Level Control - Bubbler**	Check operation	GI	
		Clean out airline	GI	
		Replace airline	PM	
B	**Couplings**	Check operation	GI	
		Lubricate	PM	
C	**Pumps - Submersible**	Pull and inspect	PM	
D	**Pumps - Dry Pit**	Check operation	GI	
		Check packing/seals	GI	
		Lubricate bearings	GI	
		Inspect belt/sheaves	GI	
		Check for vibration	PM	
E	**Valves - Air Relief**	Inspect and clean	GI	
F	**Valves - Check**	Lift arm to check operation	GI	
G	**Valves - Isolation**	Exercise	PM	
		Inspect packing seals	PM	

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

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3. .....

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4.

A _____

B _____

C _____

D _____

E _____

F _____

G _____

Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Information Sheet-3	Identifying and reporting pump station faults and carrying out minor repairs

1. Identifying and reporting pump station faults and carrying out minor repairs

This section is intended to assist operators to recognize potential problems and take actions before a major failure occurs. It is the responsibility of the operators to monitor all running equipment continuously. The following table gives typical plant abnormalities, likely causes and recommended actions.

Table 3.1 Trouble Shooting – Water Pump

Fault	Likely cause	Recommended Action
High current/excess heat (for turbine pump)	Low voltage	Stop pump, advise supervisor. Restart pump when voltage rises above 380 Volts
	Bearing beginning to seize	Stop pump, advise supervisor and maintenance personnel
Excessive vibration in pipe work	Failure of inline bearing between pump and motor (mis-alignment)	Stop pump immediately, advise supervisor and maintenance personnel
	Failure of pump bearing	
	Trapped air (following start up)	Check if pressure gauge is fluctuating- if it is vent the air.
	Pumping air water mixture due to low water level	Stop pump, advise supervisor. Inform maintenance group.
Low flow meter reading	Damaged pump unit	Check motor current – if normal continue to run pump but advise supervisor.
	Damaged flow meter	May be caused due to trapped air in flow meter. Advise supervisor to arrange venting or replacement of meter.
Low supply voltage	Incoming grid power supply	Stop pump when voltage is too low. Restart at 380 V.
Low indicated pressure	Damaged pump unit	Check motor current, if normal, continue to operate but advise maintenance personnel.
	Burst main	Check for excess flow rate, if confirmed stop pump and advise supervisor.

Pump motor fails to start	Blown fuse of open circuit breaker	Replace fuse or reset circuit breaker
	Motor of starting switch out of order	Replace and consult supplier/electrician
	Stuffing box tightly packed	Check packing and loosen
	Sand in impeller	Open pump and remove dirt
Water not delivered	Pump has lost its priming	Repeat priming
	Leaks in pipe or suction pipe	Seal the leaks
	No water in the source due to over pumping	Deepening of source
	Collapse of well casing or screens	Replace
	Clogging of well screens	Consult well driller and get it cleaned
	Wrong direction of rotation	Check direction of rotation
Pump is running, but very small amount of water is delivered	Low yield in well	Well deepening
	Air leaks in suction pipe	Pull drop pipe from well and seal the leaks
	Partial clogging of well screens	Consult well driller and get it cleaned
	Impeller is worn out	Clean/replace impellers
	Obstruction of foot valve	Clean foot valve
	Wrong direction of rotation	Check direction of rotation
Noise in pump	Bearing or other part are loose	Tighten or replace parts
	Pump motor is loosely mounted	Tighten the mounting
	Low level of water in well	Reduce pumping rate
	Air in suction pipe	Repair air leaks

Table 3.2 Trouble Shooting – Control Panel

Plant Abnormality	Likely cause	Recommended Action
Burning smell from starter panel	Overheating	Stop pump and isolate starter panel at main power switch. Check for fire. **Do not use water to extinguish fire**. Call supervisor and maintenance personnel immediately. If serious call Fire Services.
Instrumentation not functional	Instrument failure	Advise supervisor and inform maintenance personnel.

Air vessel

Table 1.3 Air vessel maintenance in the transmission line is presented in

Maintenance Duration	Activities
Daily	☞ Check air-water interface level in sight glass tube. ☞ The air water level should be within range marked by upper and lower levels and shall be preferably at middle. ☞ Check pressure in air receiver at interval of every 2 hours.
Quarterly	☞ Sight glass tube and cock shall be flushed. ☞ All wiring connections shall be checked and properly reconnected. ☞ Contacts of level control system and pressure switches in air supply system shall be cleaned.
Yearly	☞ The air vessel and air receiver shall be drained, cleaned and dried. ☞ Internal surface shall be examined for any corrosion etc. and any such spot cleaned by rough polish paper and spot-painted. ☞ Probe heads of level control system shall be thoroughly checked and cleaned.

Table1.4 Generator set Control System Fault Finding / Trouble Shooting Guide

Fault	Symptom	Remedy
Engine Fails To Start	Engine Does Not Crank When Key Switch Turned To Position " " (Start)	1. Check Operation of Key Switch. 2. Check No Fault Lamps Illuminated. Reset, If Required, After Remedying Indicated Fault. 3. Refer To Your Local Dealer.
Engine Stops Due To Low Oil Pressure (All Control Systems)	"LOW OIL PRESSURE" Fault Lamp Illuminates	1. Check Oil Level 2. Refer To Your Local Dealer.
Engine Stops Due To High Coolant Temp	"HIGH COOLANT TEMP" Fault Lamp Illuminates	1. Check Coolant Level. (Be Sure to Allow The generator set to Cool First as Hot Water/Steam Can Be Present When You Remove the Radiator Cap). 2. Refer To Your Local Dealer.
Other Faults	–	Refer To Your Local Dealer.

Table1.5 Trouble Shooting Guide for generator set

Fault	Symptom	Remedy
Engine Fails To Start	Engine Does Not Crank When Start Signal Is Given, Either Manually Via Run Key Or Automatically Via A Remote Signal	1. Check All Emergency Stop Push Buttons Are Released 2. Check The Stop Button Light Is Not On 3. Check There Are No Shutdown Events Active. Reset, If Required, After Remedying the Indicated Fault 4. Refer To Your Local Dealer
Engine Stops Due To Low Oil Pressure	"LOW OIL PRESSURE "In Event Log Red Shutdown Led Illuminates	1. Check Oil Level 2. Refer To Your local Dealer
Engine Stops Due To High Coolant Temp	"HIGH COOLANT TEMP" In Event Log. Red Shutdown Led Illuminates	1. Check Coolant Level in The Radiator. Refer to Safety Section Before Removing the Radiator Cap 2. Refer To Your Local Dealer
Engine Stops Due To Over speed	"OVERSPEED "In Event Log. Red Shutdown Led Illuminates	1. Verify The Actual Engine Speed 2. Refer To Your Local Dealer
Engine Stops Due To Under-Voltage	"UNDER-VOLTAGE "In Event Log, Red Shutdown Led Illuminates	1. Refer To Your Local Dealer
Engine Stops Due To Over-Voltage	"Over-Voltage "In Event Log, Red Shutdown Led Illuminates	1. Refer To Your Local Dealer
Generator set Does Not Go On Load	Generator set Is Running But The Load Is Not Being Powered	1. Refer To Your Local Dealer

Generator set Does Not Stop Manually	Generator set Keeps Running After Being Switched Off	1. Check That the Generator set Stops When the Emergency Stop Push Button Is Depressed 2. Refer To Your Local Dealer
Generator set Does Not Stop When In Auto Mode	Generator set Does Not Stop After Remote Start Signal Is Removed	1. Check That the Generator set Stops When The o Emergency Stop Push Button Is Depressed the Stop Key Is Held Down For 5 Seconds And The Cool down Time Is Skipped
Alarm for Not in Auto Mode (Standby Sets Only)	"Not in Auto Mode" Alarm in Event Log, Amber Led Illuminates	1.Check The Module Is in "Auto "Mode 2.Check Emergency Stop Push Buttons Are Not Pressed 3. Refer To Your Local Dealer

Self-Check 1	Written Test

Direction I: choose the correct answer to the following questions. Use the Answer sheet provided in the next page:

1. What are the possible cause of high current reading in pump operation?
   - A Low voltage
   - B Bearing being seizing
   - C High pressure in pipe line
   - D All
2. Possible cause of Excessive vibration in pipe work.
   - A Mis-alignment
   - B Failure of pump bearing
   - C Trapped air
   - D Pumping air water mixture due to low water level E.all
3. What are the possible cause of a Pump is running, but very small amount of water is delivered?
   - A Low yield in well
   - B Air leaks in suction pipe
   - C Wrong direction of rotation
   - D Impeller is worn out
   - E Partial clogging of well screens or Obstruction of foot valve F.all
4. What are the possible cause of Water not delivered?
   - A Pump has lost its priming
   - B Leaks in pipe or suction pipe
   - C Clogging of well screens
   - D Wrong direction of rotation
   - E all
5. What are the remedial action for engine fails to start?
   - A Check All Emergency Stop Push Buttons Are Released
   - B Check The Stop Button Light Is Not On
   - C Check there are no shutdown events are active and reset after the problem is resolved.
   - D All

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Choice Questions

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

Note: **Satisfactory rating - 7.5 points and above**
Unsatisfactory - below 7.5 points
You can ask you teacher for the copy of the correct answers.

Operation Sheet 1	Inspecting and making simple maintenance task

Operation title: - Inspect surface water pump and make simple maintenance task
Purpose: - to maintain proper operation of pump
Condition for the operation: - surface water pump station or fully organized demonstration site
Equipments: -

- Thee phase supply (generator set or grid electric supply)
- Switch board
- Surface water pump set
- Pressure gauge
- Gate valve
- Pressure relief valve
- Check valve

Materials: -

- Oil
- Asbestos graphite Packing

Tools: - Multimeter, screw driver, plier, spanner, bearing puller, knife
Procedure: -

1. Check the level and condition of the oil through the sight glass on the bearing frame.
2. Check for unusual noise, vibration, and bearing temperatures.
3. Check the pump and piping for leaks.
4. Adjust or replace the packing in the stuffing box if you notice excessive leaking.
5. Analyze the vibration.
6. Inspect the discharge pressure.
7. Inspect the temperature.
8. Check the seal chamber and stuffing box for leaks.

Precautions: -

- Wear protective clothing

Quality criteria: -

- The pump set should run smoothly
- There will be no water hammer
- Current reading should be the maximum permissible load current
- The pump should deliver the required discharged at the wright head
- Check the gland packing seal is dripping at the required minimum rate

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary equipments, tools and materials you are required to perform the following tasks within3hr hour

Task 1. Prepare preventive maintenance schedule for surface water pump

Task 2. Prepare preventive maintenance schedule for generator set

Task 3. Replace stuffing box packing

Task 4. Replace generator engine lubricating oil

Equipments: -

- Surface water pump set
- Generator set

Tools: - Multimeter, screw driver, plier, spanner
Materials: -Engine lubricating oil, Asbestos graphite packing

Instruction Sheet 4	Learning Guide 46: Monitor and adjust pump station performance

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

- Monitoring, Evaluation performance and reporting
- Identifying and adjusting pump station monitoring points 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 –

- Monitor, Evaluate performance and report
- Identifying and adjusting pump station monitoring points to maintain operational parameters

Learning Instructions:

42. Read the specific objectives of this Learning Guide.
43. Follow the instructions described in number 3 to 20.
44. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
45. Accomplish the “Self-check 1” in page __.
46. 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-check 1).
47. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
48. Submit your accomplished Self-check. This will form part of your training portfolio.
49. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
50. Accomplish the “Self-check 2” in page __.
51. 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-check 2).

52. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
53. Accomplish the “Self-check 3” in page __.
54. 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-check 3).
55. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Activities.

Information Sheet-1	Applying Pump station performance targets

1 Performance Evaluation

Effective evaluation of the status of operation and maintenance depends primarily on the ability to measure current performance. This can be achieved using indicators and targets for the performance of different functions.

The concept of monitoring the performance of operation and maintenance is to use the results to improve the situation. Evaluation is made through performance indicators defined as variables whose purpose is to measure change in a process or function. Indicators are collected at regular intervals through regular reports, to track the way in which a system is performing or an activity is unfolding. Indicators may be used to assess the change resulting from a particular activity. In one way, performances indicators are used to monitor the progress of the process; another way, indicators are used to evaluate the outcome of the system. Evaluation requires the situation to be assessed both at the beginning and at the end of a certain activity.
Indicators may be quantitative or qualitative in nature.

The evaluation process begins at the scheme level as reports on input; output and performance are generated and reported to utility for verification and assistance. The performance indicators under implementation by the Ministry of Water and Energy shall be measured using the records under O&M event as a basis.

1.1 Parameters to be Determined

- Head
- Discharge
- Power input to motor
- Speed of pump

1.2 specific Points

- Only one pump-motor set shall be tested at a time.
- All gauges and test instruments shall be calibrated.
- Rated head shall be generated by throttling valve on pump delivery.
- Efficiency of motor shall be as per the manufacturer's curve or type test certificate.
- Water level in the sump/intake shall be maintained practically constant and should be measured frequently (once in every 3-5 minutes).
- Test should be conducted for sufficient duration (about 30-60 minutes) for better accuracy.

1.3 Test Gauges and Instruments

Following test gauges and instruments are required for performance test.

2.1.1 Determination of head

- Pressure and vacuum gauges.
- Float gauge with calibrated scale to measure elevation difference between water levels and pressure gauge or elevation difference between two gauges.

2.1.2 Determination of discharge

- Flow meter
- In absence of flow meter, volumetric measurement preferably at both source and discharging point wherever feasible or otherwise at one of the two points which is reliable shall be carried out.

2.1.3 Input Power

- 2 numbers of single phase wattmeter
- Current Transformer (CT)
- Potential Transformers (PT)
- Test lids
- Frequency-meter D. Speed
- Contact tachometer or
- Non-contact optical tachometer

2 Monitoring performance

The main objective of monitoring and evaluation is to compare plan against accomplishment to determine if there are deficiencies and take corrective action if needed so as to manage time, cost and quality of service provided by the maintenance system.

The purpose of reporting is to inform management and other responsible parties as to the progress of maintenance activities and any needed changes in operating procedures or resource requirements.

The utility management and the board shall regularly monitor the performance of the utility related to the plan using selected performance indicators which can be base to measure its performance and compare its standard to other similar utilities.

3 Reporting pump station performance

Reporting is an indispensable part of all management functions and provides the key input to performance evaluation.

Technical personnel of the Water Supply Service /WSS/ shall understand the value of the records and keep the forms filled and in their routine operation activity and make the reporting process realized. Such record reports allow management to measure performance and compare actual performance with standards and targets. The results may indicate that corrective action is required to obtain conformity with the plan.

Table 1.1 Type and Source of Reports

No.	Type of Report	Source
1.	Daily/occasionally Technical Operation Daily Technical Maintenance Report	Scheme operator daily fills out the prepared forms and keeps in a water proof binder submits by the end of the month
2.	Monthly/occasionally Operation and performance Report Maintenance Report	Utility
3.	Annually Performance Report Maintenance Report	Utility

The utility is required to know the importance of reporting and make sure that all forms generated in the operation and maintenance activities are complete and filed as per table indicated below for the use of the different management level, when the need arises. The filing system of these technical reports shall be made as shown in table below:

Self-Check -1	**Written Test**

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. What is the main objective of monitoring and evaluation? (5 points)
2. Effective evaluation of the status of operation and maintenance depends primarily on _____ (5 points)
3. Define performance indicators. (5 points)
4. What are the parameters to determine in performance testing (5 points)?

Answer Sheet-1

Name: _____ Date: _____

Short Answer Questions

1. .....
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2. .....
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3. .....
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4. .....
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Score = _____

Rating: _____

Information Sheet-2	Identifying and adjusting pump station monitoring points to maintain operational parameters

1 Pump station monitoring points and adjustment to operational parameter

Pump instrumentation will allow for control and monitoring of the pump and station equipment. Monitoring will also include all trending and alarming functions. The following is the minimum pumping control instrumentation.

1.1 Magnetic Flow Meters at Discharge of Pump

The programmable logic controller (PLC) should be programmed to calculate the flow totalizing function. The flow meters should be specified with reverse flow sensing capability to detect a check valve malfunction for systems that will not have motor operated discharge valves. Magnetic flow meters should be used to the extent possible, with submergence ratings, and remotely mounted transmitters. Magnetic flow meters should be in-line type and installed on the discharge of each pump rather than a single flow meter being provided on a discharge header. Totalizing functions should be performed through the SCADA system or directly in the corresponding PLC.

1.2 Low-Pressure Pump Suction Pressure Gauges, Transmitters, and Mechanical Switches on Suction Side of Each Pump

Switches should typically be adjustable from 0 to 15 psi and should provide a low suction pressure trip directly to the pump controls for equipment safety. Transmitters and gauges should have the same usable range and should be used for PLC control and monitoring and local reading, respectively. The switch trip should also be sensed at the PLC, either through a dual switch contact or repeated from the pump local control panel. The analog signal should only be wired to the PLC. The low-suction pressure switches should specifically use a local control panel reset to restart the pumps. This setup requires SPU to do a local inspection before pump restart.

1.3 High-Pressure Pump Discharge Pressure Gauges and Transmitters on Discharge Side of Each Pump

Transmitters and gauges should operate from 0 to 100 psi. The transmitter should have programmable contacts for high pressure to directly shutdown the pump controls and should provide an analog signal to the PLC for control and indication.

1.4 Open/Close Limit Switches for all Pump Isolation Valves

These limit switches should be equipped with dual contacts. One set of contacts should be used for local pump control panel interlocks. The other set is used for PLC control and monitoring. Alternatively, single contact switches can be used and the signals repeated from the local control panel to the PLC.

1.5 Pump and Motor Vibration Switches

The motor for each pump above 50 hp should be monitored for vibration. The vibration monitors should be specified to be as manufactured specification

- Two limit switches for each pump: one for alarm and one for pump shutdown; each limit should be independently adjustable.
- A display to show the current status of the velocity level.
- Manual reset button to reset the monitor and relays to the non-alarm state.
- Test button for each channel to trip the alarm for testing with and without pump shutdown.
- Time delay for each limit to be independently adjustable from 2 to 15 seconds.
- An illuminated indicator per channel and limit to light after the time delay when any set point is exceeded.
- A trip light to illuminate immediately when any set point is exceeded and before alarm or shutdown is initiated.
- A circuit checker with illuminated indicator to continuously light when the pickup circuit is working properly.

1.6 Wet Well Level Transmitters

Water label sensors should be connected to control panel

2 Instrumentation and Monitoring for Drinking Water Pump Stations

The pump station data/instrumentation standard includes all drinking water pump stations for the distribution system. Typical pump station standard equipment and signals are described is this section.

2.1 SCADA Control Panel

The equipment that controls a pump station must be housed in a SCADA PLC panel. The panel contains a pump station PLC, supporting instrumentation, and accessories and appurtenances required to control and monitor the pumps. Additional control interfaces may be needed to monitor buildings auxiliary HVAC, fire alarm, and security systems.

A local Operator Interface or Human Machine Interface (OI/HMI) can be provided as an option on the SCADA panel for local control and indication. The OI has the capability to display, store, and reset alarm conditions and trends.

For detailed information on SCADA panel requirements, see *DSG Chapter 10, Instrumentation & Control*.

At most SPU sites, standard control panel signals are provided on the existing SCADA.

Additional signals should be added at any sites that do not include all standard signals. Standard control panel signals include the following:

- Control Panel AC Power Failure Alarm
- Control Panel PLC Battery Voltage Alarm
- Control Panel PLC Battery Charger Alarm
- Control Panel Door Open Alarm
- PLC Key State (PROGRAM-REMOTE-RUN)
- PLC Communication Fail Alarm
- Batteries Voltage – Analog Signal

2.2 Pump Station Suction Pressure

The suction pressure monitoring at a pump station measures the pressure at the upstream side of the pump suction connections and downstream of the station inlet or storage facility connection.

2.3 Pump Station Discharge Pressure

A pump station discharge pressure transmitter measures the pump station discharge pressure and sends the signal to the PLC, then to the SCADA operator.

.

2.4 Pump Station Discharge Flow

Pump station discharge flow rate is measured by a flow meter between the pump discharge header and the discharge zone.

2.5 Pump Station Discharge Pressure High Alarm

The discharge pressure high alarm signal is provided either by a pressure switch connected to the pump station discharge line or by PLC logic, which monitors the analog signal from the discharge pressure transmitter. The alarm can be used either to provide an alarm only to the SCADA operator or to stop the pumps with either PLC logic or a hardwired interlock. An alarm is sent to the SCADA operator.

Discharge pressure high switches must be added at all pump stations as a basic instrument.

2.6 Pump Station Flood Alarm

The pump station flood float switch detects a high water level or flood condition in the pump station building.

2.7 Pump Station Fire Alarm

The pump station high heat sensor detects a possible fire in the pump station building and a fire alarm signal is registered in the SCADA PLC.

2.8 Pump Station Electrical Power Fail Alarm

The pump station AC power fail condition is detected with a power fail relay or a more sensitive phase failure relay that monitors the incoming power at the pump station.

2.9 Pump Running

Pump running status is monitored by a run contact in each pump motor starter. The run status signal is sent to the PLC, then to the SCADA operator workstation.

2.10 Pump Local-Off-Remote Switch

Each pump in the pump station must be equipped with a Local-Off-Remote (L-O-R) switch. The status of each pump must be monitored by the SCADA PLC.

When this switch is in the *remote* position, the signal is a permissive for a pump remote start command to the respective pump. All SPU pump stations currently include this status signal.

The *off* and *local* position status signals must be added as basic data inputs to the PLC and monitored by the SCADA system.

2.11 Pump Start and Stop Commands

The PLC sends a pump start (or stop) command to each pump motor starter when the pump is required to run (or to stop). The PLC outputs the pump start/stop command only when the pump L-O-R switch is in the Remote position, and a command is received from the operator HMI.

2.12 Pump Available Status – Calculated

The pump available status is calculated by the PLC and is true when the L-O-R switch is in Remote position and there are no pump alarms. SPU should add this status signal to allow the SCADA operator and automatic control applications to prepare for pump start.

2.13 Pump and Motor Bearing High Temperature Alarms

Bearing inboard and outboard high temperature switches must be interfaced to the PLC.

An additional relay may be required to add a dry contact for PLC input.

2.14 Motor Overload Alarm

Motor overload relays must be interfaced to the PLC. An additional relay may be required to add a dry contact for PLC input.

2.15 Pump Discharge Valve Status

Where pump discharge valves are installed, the open and closed status must be monitored by the SCADA system PLC to provide an alarm if the valve is not open when the pump is running. The pump discharge valve position status switches should be added as a basic data requirement.

2.16 Intrusion or Security

Intrusion switches and vault security alarms should be added as basic data for water quality security and site security purposes at pump station sites.

2.17 Pump Station Electrical Power Consumption (optional)

Electrical power total consumption in kilowatt (kW) and energy consumption rate in kilowatt hour (kWh) should be measured at the station, input to the PLC and sent to the SCADA system and operator at less than 15-minute intervals. SPU does not currently monitor electrical power consumption at its pump stations.

Power monitoring should be added at SPU pump stations as advanced data.

Electrical power consumption data can be used to check the power company billing information on a monthly interval and is required at 1 to 5-minute intervals to calculate pump efficiency.

Self-Check -1	**Written Test**

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. List pump station monitoring points. (5 points)
2. List pump station monitoring instruments. (5 points)

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

1.

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2.

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Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Instruction Sheet 5	Learning Guide 47: Check outsourced maintenance work

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

- Checking completed maintenance and repairs
- Checking return of pumping station to service

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 completed maintenance and repairs
- Check return of pumping station to service

Learning Instructions:

56. Read the specific objectives of this Learning Guide.
57. Follow the instructions described in number 3 to 20.
58. Read the information written in the "Information Sheets 1". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
59. Accomplish the "Self-check 1" in page __.
60. 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-check 1).
61. If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
62. Submit your accomplished Self-check. This will form part of your training portfolio.
63. Read the information written in the "Information Sheet 2". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
64. Accomplish the "Self-check 2" in page __.
65. 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-check 2).
66. Read the information written in the "Information Sheets 3 and 4". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
67. Accomplish the "Self-check 3" in page __.

68. 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-check 3).

69. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Activities.

Information Sheet-1	Checking completed maintenance and repairs return to service

Outsourcing Maintenance

Outsourcing maintenance is the transfer of a maintenance to an external service provider. Maintenance service should encourage active participation of private sector in the operation and maintenance services and expansion of water supply service hence the utility need to study and decide on the type of maintenance and operation works which can be handled by the utility's own force and those which can be done by external service providers. The decision shall mainly depend on the cost benefit analysis for the utility. The utility shall always plan to improve its performance to cope up with the current technological and information standards. To achieve this, the utility shall practice outsourcing of required services beyond their capacity by preparing appropriate terms of references and specifications Pump Station

Checking completed maintenance and repairs

A well-defined plan is critical to successful testing and startup. This process begins with factory performance testing of the equipment (where applicable), and is completed with final approval of all checklist items and successful operation of the pump station through the test period.

The following activities should be performed when commissioning outsourced pump maintenance

1 Check electrical condition of insulation on power cable(s) and on all phases of the motor (in Meg Ohms).
2 Check for any loose or faulty electrical connections within the control panel
3 Measure resistance between stator windings (in Ohms).
4 Check voltage supply between all phases of the electrical control panel.
5 Check voltage balance between all phases on the load side of the pump / mixer control panel with pump / mixer running (VAC).
6 Check amperage draw on all phases of the motor (in Amps).
7 Check condition and operation of the motor thermal protection control system (if equipped).
8 Removal of pump / mixer from the lift station for physical inspection.
9 Check condition of upper and lower shaft seals (inspect condition of motor / stator housing, if applicable).
10 Check condition and operation of leakage and bearing sensors (if equipped).
11 Drain oil from oil housing and replace with new oil.
12 Check for worn or loose impeller or propeller.
13 Check impeller wear rings (rotating & stationary)

14 Adjust clearances as needed for optimal operation.
15 Check for any unusual noise in the upper and lower bearings.
16 Clean, reset and check operation of the level control system (if equipped).
17 Check for physical damage of power and control cables.
18 Check for correct shaft rotation.
19 Reinstall the pump / mixer and check operation (if liquid level in the station permits).
20 Test the pump / mixer operating cycle, under load (if liquid level in the station permits).
21 Perform draw down test on pumps to establish GPM being produced (when possible).
22 Perform shut off head test on pumps to establish pressure being produced (when possible).
23 Check operation of valves and associated equipment

Self-Check -1	**Written Test**

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. What is outsourcing maintenance. (5 points)
2. List activities should be performed when commissioning outsourced pump maintenance (5 points)

Answer Sheet-1

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

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2.

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Note: **Satisfactory rating - 7.5 points and above** **Unsatisfactory - below 7.5 points**

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

Instruction Sheet 6	Learning Guide 48: Finalise 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*
- Restoring work site
- Maintaining workplace records

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*
- Restore work site
- Maintain workplace records

Learning Instructions:

70. Read the specific objectives of this Learning Guide.
71. Follow the instructions described in number 3 to 20.
72. Read the information written in the "Information Sheets 1". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
73. Accomplish the "Self-check 1" in page __.
74. 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-check 1).
75. If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
76. Submit your accomplished Self-check. This will form part of your training portfolio.
77. Read the information written in the "Information Sheet 2". Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
78. Accomplish the "Self-check 2" in page __.
79. 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-check 2).

80. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
81. Accomplish the “Self-check 3” in page __.
82. 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-check 3).
83. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Activities.

Information Sheet-1	Checking, maintaining and storing equipment, tools and materials

Maintaining tools and equipments

Routine maintenance of hand and power tools is performed in accordance with organizational guidelines and manufacturer's specifications.
General hand tools maintenance includes the following

a. Painting
b. Cleaning
c. Sharpening
d. Lubricating
e. Repairing
f. Tightening
g. Testing

Cleaning hand Tools

Cleaning your tools regularly extends their life and allows you the opportunity to ensure they remain free from rust if they have metal parts and apply lubricant.

Cleaning the tools regularly is essential to their proper functioning. After a day of work, your tools will be covered with some amount of dirt. It's important to clean them after you're finished using them. When cleaning your tools, don't use chemicals that are extremely harsh. Follow the manufacturer's guidelines for proper cleaning and maintenance**.**

The Cleaning Process:

1. Make sure you wear heavy duty gloves when handling hand tools, especially hand tools with sharp cutting edges.
2. Always check the manufacturer's directions and recommendations for proper cleaning and maintenance of your tool(s), and follow any such instructions carefully.
3. Disconnect all power cords from the tool being cleaned.

4. Wet a cleaning rag with the cleaning solution and wring out thoroughly so that it is just damp, not wet or dripping. Wipe down the surface of the tool. Avoid getting water in or around the power cables or motor casings.
5. Check any exposed metal parts of the tool for rust. If there is any rust, remove it by rubbing briskly with the steel wool.

Lubricate tools.

Whether you work with pneumatic or regular tools, it is important to lubricate them regularly. Lubricating tools helps them to perform better and reduces wear and tear of components.

Lubrication is even more important when working with air or pneumatic tools. Pneumatic tools need to be lubricated once a day before use. When moisture or condensation enters the interiors of pneumatic tools, it can cause corrosion. Corrosion can decrease the life of an instrument. Corroded parts are difficult to repair and replace. Hence, the internal components of pneumatic tools should be coated with special air-tool oil. This oil prevents corrosion by displacing any moisture that enters the interior of the equipment.

Storing equipments and materials

Safe storage of materials and equipment is essential for many businesses, such as construction job sites, laboratories, and other locations that handle chemicals, flammable gases and other hazardous materials. Storage methods and procedures are regulated for many such items; when in doubt it is always best to be cautious to prevent accidents. Locking storage cabinets and restricting access to storage areas will prevent unauthorized handling of stored items and minimize the possibility of theft.

Requirements for Storing Materials Indoors

Storing materials indoors requires attention to access, fire prevention and protection, floor loading, and overhead hazards. Buildings under construction require special precautions. Access. Place or store materials so they do not interfere with access ways, doorways, electrical panels, fire extinguishers, or hoist ways. Do not obstruct access ways or exits with accumulations of scrap or materials. Aisles must be wide enough to accommodate forklifts or firefighting equipment.

Fire Prevention: When storing, handling, and piling materials, consider the fire characteristics. Store non compatible materials that may create a fire hazard at least 25 feet apart or separate

them with a barrier having at least a 1-hour fire rating. Pile material to minimize internal fire spread and to provide convenient access for firefighting.

Fire Doors: Maintain a 24-inch clearance around the travel path of fire doors.

Sprinklers: Maintain at least an 18-inch clearance between stored materials and sprinkler heads.

Heating Appliances: Maintain at least a 3-foot clearance between stored materials and unit heaters, radiant space heaters, duct furnaces, and flues or the clearances shown on the approval agency label.

Fire Protection: Emergency fire equipment must be readily accessible and in good working order.

Self-Check -1	**Written Test**

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. What are the tasks performed during hand tools maintenance? (5 points)
2. Discuses hand tool cleaning procedure. (5 points)
3. Describe the purpose of lubricating hand tools. (5 points)

Answer Sheet-1

Name: _____ Date: _____

Short Answer Questions

1. .....
   .....
   .....
   .....
2. .....
   ..
3. .....
   .....
   .....
   .....

Score = _____

Rating: _____

Information Sheet-2	**Maintaining workplace records**

Maintaining workplace records

Reporting is an indispensable part of all management functions and provides the key input to performance evaluation.

Technical personnel of the Water Supply Service /WSS/ shall understand the value of the records and keep the forms filled and in their routine operation activity and make the reporting process realized. Such record reports allow management to measure performance and compare actual performance with standards and targets. The results may indicate that corrective action is required to obtain conformity with the plan

Reporting defects

A pump operator should report defects immediately:
if a defect is considered to be a hazard to safety, pumping operations should be stopped until the defect is repaired.
The details of reported defects and subsequent action taken should be entered into a log book

Log books and inspection record sheets

Instruction, maintenance and repair manuals should be kept in a safe place at the registered premises, and should include a parts catalogue.
The operator should be familiar with the contents of the instruction manual which should be available at the site of operation.
All log books and inspection record sheets must show complete details of all inspections, tests, repairs, replacements and modifications carried out on equipment, and be available for inspection by the principal contractor or person in control of the workplace.
Evidence that the pump and other equipment has been inspected and certified to be 'suitable for continued service' (i.e. in a safe working condition), should be made available to the principal contractor or person in control of the workplace for inspection (on request), before the unit is allowed to operate on site.

Record keeping routine operations/maintenance procedures

This section provides a description of the routine operation and maintenance (O&M) procedures designed to maximize operating techniques and preventative maintenance to ensure proper operation of the system.

Part 1
Start-up and Shutdown of Operations

Describe what controls the start-up of your water source (automatic or manual). If automatic, what activates the pump? (pressure switch, water level controls)

_____

_____

Describe what controls the shut-down of your water source (automatic or manual). If pressure related, at what pressure does the pump shut off?

_____
_____
_____

Describe what controls water levels in the storage unit (altitude valve, float, pressure).

_____
_____
_____

Describe what controls the start-up of disinfection/other treatment processes.

_____
_____
_____

Describe what controls the shut-down of disinfection/other treatment processes.

_____
_____

Daily Operations:

List and describe the daily tasks performed with the frequency and who is responsible for performing that task

Example: check gauges, visual inspection of well, measure disinfection residual, visual inspection of pumps _____

_____
_____

Routine Operations:

List and describe the tasks performed other than daily (weekly, monthly, annually, as needed) with the frequency and who is responsible for performing that task

Examples: Exercise valves, flush hydrants,

_____
_____
_____

Emergency Flags - An emergency exists when:

- water pressure falls below _____ psi
- entry point chlorine residual is less than _____ ppm
- other (describe) _____
  _____

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 pumped, chemical quantities, and routine test results. This report is submitted monthly following the month for which the records contained in the report are compiled,
A copy of the Daily Start-up Checklist should be kept at the well house and/or treatment plant. 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.

Copies of the above reports are filed at _____
Distribution maps are located at _____
Technical Manuals are located at _____

Example Daily Start-up Checklist

Inspected by: _____ Date: _____

- ☐ Well pump operational (flow rate and pressure normal)
- ☐ Disinfection process operational (adequate feed chemical available / design residual achieved)
- ☐ Other treatment process operational (adequate feed chemical available / design residual achieved)
- ☐ performed physical inspection of pump, tubing, injection assembly
- ☐ performed mechanical inspection of piping, motors, sumps
- ☐ performed electrical inspection of wires, fuses
- ☐ other (describe)
- ☐ Recorded water flows
- ☐ Recorded water pressure
- ☐ Recorded chlorine residual
- ☐ Recorded other chemical feed residuals

Additional start-up step(s):

_____

_____

_____

_____

_____

_____

_____

_____

_____

Weekly / Monthly Inspection Report

Inspection of:	Observations/Initials	Date / Time

Maintenance Activity Report

Activity Performed:	Location	Initials / Date

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**

Part 2 - Equipment Inventory

This section identifies our on-site inventory of equipment and spare parts including safety equipment such as eye washes, fire extinguishers, first aid kits, etc.

Equipment Description	Location	Quantity

Part 3 – Spare Parts Inventory

Auxiliary Power Sources

Type/Capacity	Location

Spare Pumps

Type/Manufacturer	Service Capabilities	Location

Spare Pump Parts

Part	Location

Spare Distribution Parts

Part	Location

Spare Treatment Parts

Part	Location

Reserve Chemicals

Chemical	Location

Part 4 - Equipment Repair/Supply Contact Information

Organization	Contact	Phone (day)	Phone (24/7)
Electrician			
Plumber			
Pump Specialist			
Soil Excavator/ Backhoe Operator			
Equipment Rentals			
Equipment Repairman			

SCADA Repair			
Pump Supplier			
Well Driller			
Pipe Supplier			
Analytical Lab			
Chemical Supplier			
Other			

Self-Check -1	**Written Test**

Direction I: Give short answer to the following questions. Use the Answer sheet provided in the next page:

1. Discuss how to report defects occur pump operation. (5 points)
2. What should be reported in case of startup and shut down operation? (5 points)
3. Define performance indicators. (5 points)
4. what kinds of reports are included routine record keeping (5 points)?

Answer Sheet-1

Name: _____ Date: _____

Short Answer Questions

1. .....
   .....
   .....
   .....
2. .....
   ..
3. .....
   .....
   .....
   .....

Score = _____

Rating: _____

References

- Dhaka Water Supply and Sewerage Authority Operation and maintenance manual for pump stations volume 2
- Grundfos Academy Basic Pump Principles
- Maharashtra Jeevan Pradhikaran (MJP) CEPT University 2012 Module 2 OPERATION AND MAINTENANCE OF WATER SUPPLY SYSTEM
- WEI/AJA LLC 143A LeFleurs Square Jackson, MS 3921 February 28, 2014 Pump Station Preventative Maintenance Programs
- Inter-American Development Bank EVALUATION OF WATER PUMPING SYSTEMS Energy Efficiency Assessment Manual First Edition
- Ministry of Ethiopian Water, Irrigation and Electricity (October, 2015) Trainer's Manual for Technical Operation and Maintenance Requirements for Rural Piped System
- EVALUATION OF WATER PUMPING SYSTEMS Energy Efficiency Assessment Manual First Edition

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