Ethiopian TVET-System

ELECTROMECHANICAL EQUIPMENT OPERATION AND MAINTENANCE

NTQF Level –III

Based on Feb, 2017G.C. Occupational Standard

Module Title: Install and Maintain Mechanical Pumps, Compressors and Blowers

TTLM Code: EIS EME 3 TTLM 0920v1

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This module includes the following Learning Guides

LG:65 Plan and prepare for the work

LG Code: EIS EME3 M09 Lo1-LG-65

LG:66 Remove pumps for maintenance

LG Code: EIS EME3 M09LO2-LG-66

LG:67 Maintain pumps

LG Code: EIS EME M09LO3-LG-67

LG: 68 Replace/install pumps

LG Code: EIS EME M09LO4-LG-68

LG:69 Complete the work

LG Code: EIS EME M09LO5-LG-69

Instruction Sheet - 1	Learning Guide #25: Plan and prepare for the work

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

- Identifying and clarifying Work requirements from request/work orders
- Identifying, applying and monitoring Occupational Health and Safety standards
- Identifying, obtaining and inspecting Resources
- Selecting and interpreting plans, drawings and texts
- Determining, obtaining and inspecting the size, type and quantity of component
- Planning Work in detail
- Resolving the Coordination requirements that affected by the work
- Identifying and preventing Potential hazards and selecting control measures
- Preparing work area in accordance with work requirements and site procedures
- Identifying teams and individuals' roles and responsibilities within the team

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 clarify Work requirements
- Identify, apply and monitor Occupational Health and Safety standards
- Identify, obtain and inspect Resources to satisfy the work plan
- Select and interpret plans, drawings and texts in accordance with the work plan
- Determine, obtain and inspect the size, type and quantity of materials/ component
- Plane Work in detail including sequencing and prioritizing and considerations made
- Resolve the Coordination requirements that affected by the work
- Identify and prevent Potential hazards and select control measures
- Prepare work area in accordance with work requirements and site procedures
- Identify teams and individuals' roles and responsibilities within the team

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 10”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3,4,5,6,7,8,9 and 10” in each information sheets on pages 7,11,13,19,35,38,43,48,52 and 55.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1 and 2 on pages 56 and 56.and do the LAP Test on page 57”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Identifying and clarifying Work requirements from request/work orders

1.1 Introduction to a work order/ work request

A work order is a document that provides all the information about a maintenance task and outlines a process for completing that task. Work orders can include details on who authorized the job, the scope, who it's assigned to, and what is expected.

A work order and work request sound similar, they have a few key differences. A work request is used by non-maintenance staff to make the maintenance team aware of a task. For example, a pump operator might submit a work request when equipment breaks down. The work request is reviewed by a maintenance manager, who adds extra information, schedules the task, and assigns it to a technician. The work request is now a work order

1.2 Generate and complete a maintenance work order

Work orders are like anything else your facility produces — they must be made well and free of defects. If one part of the process is off, it can affect the entire line. So, what information makes up a great work order

- **Asset:** What piece of equipment needs work?
- **Description of issue:** What's the problem? What did you hear, see, smell, or feel at the time of failure or leading up to it?
- **Scope of work:** What work is required to get the job done? What skills are needed?
- **Parts and tools required:** Are there any parts that need to be replaced or special tools that need to be used?
- **Health and safety notes:** What safety procedures and equipment are needed? Have there been any accidents or near-misses while working on a similar issue or asset?
- **Date requested:** When was the work order created and submitted?
- **Requester name/department/contact:** Who created and submitted the work order?
- **Expected completion date:** When should this work order be completed?

- **Actual completion date:** When was the work order completed and closed?
- **Expected hours of work:** How many hours should it take to complete the work order?
- **Actual hours of work:** How many hours did it take to complete the work order?
- **Task checklist:** Is there a step-by-step guide to completing the required work?
- **Priority:** How important is this work order? High, medium, or low?
- **Assigned to:** Who will be doing the work? Is more than one person required? Is an outside contractor required?
- **Associated documents:** Are there resources that can help the work order be completed more efficiently, like SOPs, manuals, diagrams, videos, asset history, purchase orders, or images?
- **Notes:** Are there any other observations that might be helpful in completing the work order or reviewing the work order after it closes, such as the frequency of an issue, troubleshooting techniques, or the solution reached?

1.3 Generate work orders for maintenance

Work orders (WOs) can be created manually or generated via the preventive maintenance PM) Scheduler.

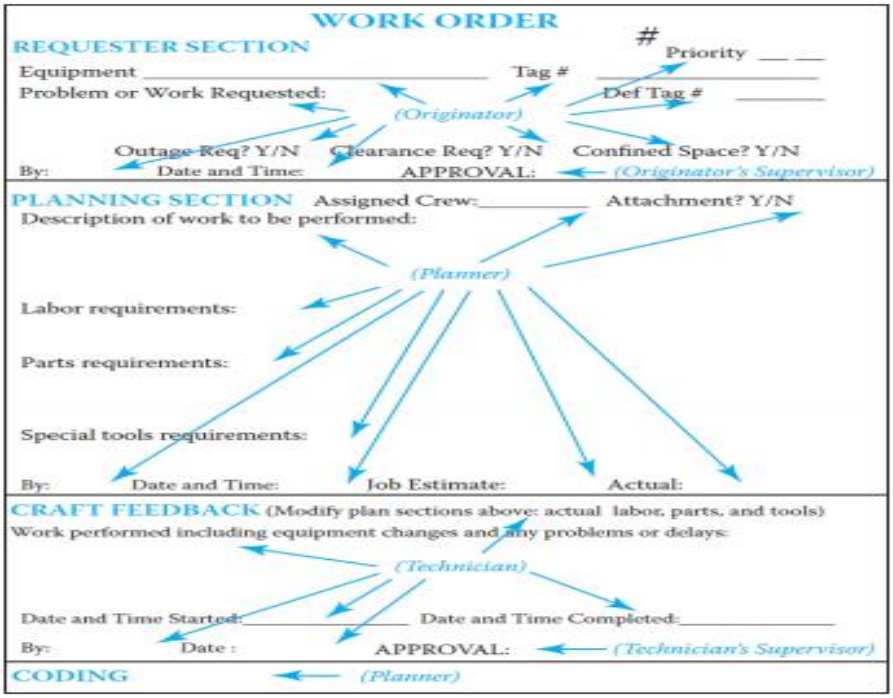


Fig 1.1 blank sample for generate work orders and its Identification of information

1.4 COMPLETE WORK ORDER

After generating a work order the work order can be used to perform the tasks as they are defined on the work order. Once the tasks are completed, then the work order is ready to be completed and finalized in the system.

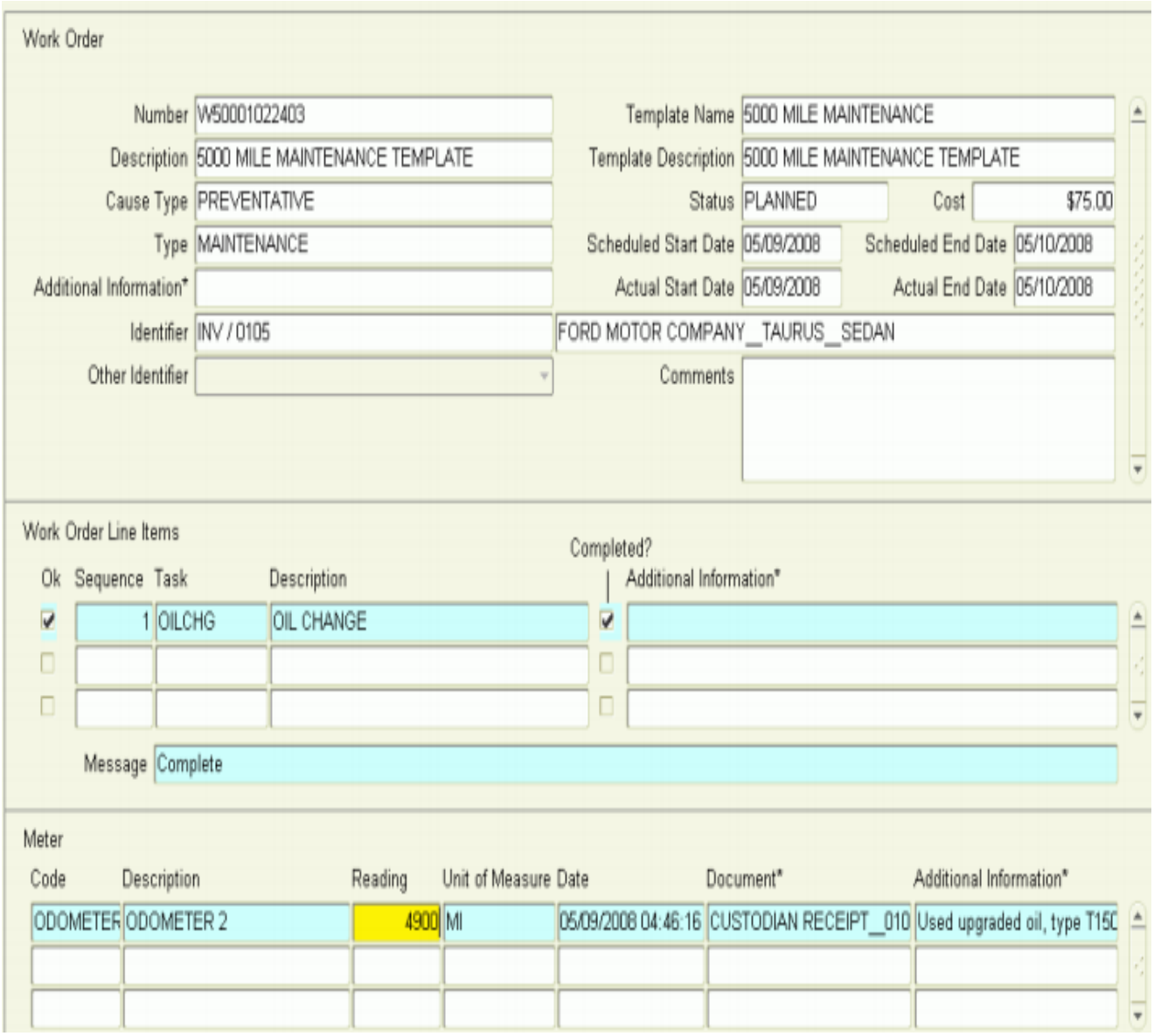


Fig 1.2 sample for complet work orders

Self-Check -1	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided:

1. A work order is a document that provides all the information about a maintenance task and outlines a process for completing that task.
   A. True B. False
2. Every maintenance work order has a lifecycle with three main phases.
   A. True B. False
3. Which one of the following is maintenance work order phase?
   A. creation B. completion C. recording. D. All
4. Work orders are crucial to an organization's maintenance operation.
   A. True B. False
5. Work orders are like anything else your facility produces — they must be made well and free of defects.
   A. True B. False

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Answer Sheet-1

Name: _____Date: _____

Score = _____

Answers

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

Information Sheet-2	Identifying, applying and monitoring Occupational Health and Safety standards

2.1 Introduction Occupational Health and Safety standards (OHS)

Occupational Health and Safety is the discipline concerned with preserving and protecting human resources in the workplace.

2.1.1 OHS guidelines

Occupational safety and health are an extensive multidisciplinary field, invariably touching on issues related to scientific areas such as medicine – including physiology and toxicology ergonomics, physics and chemistry, as well as technology, economics, law and other areas specific to various industries and activities. Despite this variety of concerns and interests, certain basic principles can be identified, including the following:

All workers have rights: - Workers, as well as employers and governments, must ensure that these rights are protected and must strive to establish and maintain decent working conditions and a decent working environment. More specifically: work should take place in a safe and healthy working environment conditions of work should be consistent with workers' well-being and human dignity; work should offer real possibilities for personal achievement, self-fulfillment and service to society.

OHS policies must be established: - Such policies must be implemented at both the national (governmental) and enterprise levels. They must be effectively communicated to all parties concerned.

Continuous improvement of occupational safety and health must be promoted: - This is necessary to ensure that national laws, regulations and technical standards to prevent occupational injuries, diseases and deaths are adapted periodically to social, technical and scientific progress and other changes in the world of work.

Education and training are vital components of safe, healthy working environments Workers and employers must be made aware of the importance of establishing safe working procedures and of how to do so. Trainers must be trained in areas of special relevance to particular industries, so that they can address the specific occupational safety and health concerns.

Workers, employers and competent authorities have certain responsibilities, duties and obligations: - For example, workers must follow established safety procedures; employers must provide safe workplaces and ensure access to first aid; and the competent authorities must devise, communicate and periodically review and update occupational safety and health policies.

2.1.2 Occupational safety and health aspects of maintenance

Maintenance is one of the workplace activities that can affect the health and safety not only of the workers directly involved in it, but of other workers and even members of the public, if safe work procedures are not followed and the work is not done properly.

Maintenance activities can cause harm to workers and others in three main ways:

- **an accident/injury may occur during maintenance** — for example, workers repairing a machine may be injured if the machine is switched on by mistake, if they are exposed to dangerous substances, or if they have to adopt awkward postures;
- **poor-quality maintenance**, for example, using the wrong parts for replacement or repair, may result in serious accidents;
- **lack of maintenance** may not only shorten the lifespan of equipment or machine, but may also cause accidents— for example, unrepaired damage to the floor of a warehouse may cause a forklift accident, injuring worker/s, but also causing damage to the property
- **lack of maintenance** may not only shorten the lifespan of equipment or machine, but may also cause accidents— for example, unrepaired damage to the floor of a warehouse may cause a forklift accident, injuring worker/s, but also causing damage to the property

2.3 Pump safety.

Specific hazards related to operating and servicing pumps include rotating equipment, lifting heavy machinery, using hand tools, working with electrical devices, and fires.so you have to follow some tips followed blew

2.3.1Some important safety tips related to maintenance actions for pumps:

- **Safety apparel**
  - ✓ Insulated work gloves when handling hot bearings or using bearing heater.
  - ✓ Heavy work gloves when handling parts with sharp edges, especially impellers.
  - ✓ Safety glasses (with side shields) for eye protection, especially in machine shop area.
  - ✓ Steel-toed shoes for foot protection when handling parts, heavy tools, etc.
- **Safe operating procedures**
  - ✓ Coupling guards: Never operate a pump without coupling guard properly installed.
  - ✓ Flanged connections: -
    - Never force piping to make connection with pump.
    - Ensure proper size, material, and number of fasteners are installed.
    - Beware of corroded fasteners.
  - ✓ When operating pump: -
    - ✓ Do not operate below minimum rated flow, or with suction/discharge valves closed.
    - ✓ Do not open vent or drain valves, or remove plugs while system is pressurized.
- **Maintenance safety**
  - ✓ Always lock out power.
  - ✓ Ensure pump is isolated from system and pressure is relieved before any disassembly of pump, removal of plugs, or disconnecting piping.
  - ✓ Pump and components are heavy.
  - ✓ Failure to properly lift and support equipment could result in serious injury.
  - ✓ Observe proper decontamination procedures.
  - ✓ Know and follow company safety regulations.

- ✓ Never apply heat to remove impeller

Self-Check -2	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided: and each contains 2pts.

1. Occupational health and safety encompass the social, mental and physical well-being of workers that is the “whole person.

   A. True B. False

2. Occupational safety and health programs and policies must aim at_____ both

   A. prevention B. protection C. both prevention and protection D. detection

3. Personal protective equipment, commonly referred to as_____

   A. PPE B.PSE C.PES D. ppd

4. All personal protective equipment should be_____

   A. safely designed and constructed in good shape

   B. Should be kept clean

   C. fit comfortably, but not loose-fitting.

   D. All

5. , Which of the following is not Safe operating procedures of pump

   A. operate a pump without coupling guard properly installed

   B. Do not operating pump below minimum rated flow.

   C. Do not open vent or drain valves, when operating pump

   D. never force piping to make connection with pump.

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

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

Information Sheet-3	Identifying, obtaining and inspecting Resources

3.1 Introduction to Resources

There are different types of resource used to install and maintain mechanical pump

- **Material resource:** a resource used for pump maintenance such as hand tools and equipment. Example Micrometers, vernier caliper, dial indicators, slip gauges, spanners, digital height gauges, grinders, jigs and fixtures, thermal blankets, induction heaters, thermal crayons, digital thermometers, oxyacetylene and appropriate lifting devices.
- **Human resource:** are the people who assigned to do the work force in the organization or in the maintenance sectors according to their skills or professionals (in electro-mechanical).
- **Financial resource:** -the budget allocated for the maintenance cost, fuel and oil cost and covering all financial funds of the organization.
- **Time resource: -**the most important resource in the world is time resource. Time resource is limited resource because once it passed it never back again.

3.2 Inspecting resource

Site Assessment and Preparation: Proper component location and site preparation have a very important impact on completing successful installation. The major components and sources of power needed for installation include the following items:

- Pump set
- Control bored
- Electrical utility

Self-Check -3	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided and each contains 2pts**.**

1. _____a resource used for pump maintenance and installation such as hand tools and equipment.

   A. Material resource B. human resource C. financial resource D. time resource

2. One the following resource is not return back again

   A/ human resource B/ material resource C/ time resource D/ finance resource

3. Proper component location and site preparation have a very important impact on completing successful installation.

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

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3. _____

Information Sheet-4	Selecting and interpreting plans, drawings and texts

4.1 Introduction to plans, drawings and texts

Drawing is a suitable graphic language from which any trained person can visualize the required object. It displays the exact picture of an object; it obviously conveys the same ideas to every trained eye.

Drawing is used by engineers, technicians, and skilled craftsmen. Whether this drawing is made freehand (sketching) or by the use of drawing instruments (mechanical drawing), it is needed to convey all the necessary information to the individual who will fabricate and assemble the object be it a building, ship, aircraft, or mechanical device.

Plans are a set of drawings or two-dimensional diagrams used to describe a place or object, or to communicate building or fabrication instructions. Usually plans are drawn or printed on paper, but they can take the form of a digital file.

4.2 Classification of drawings

In these sections we see most drawing types used in maintenance and installation of machine

4.2.1 Machine drawing

It is pertaining to machine parts or components. It is presented through a number of orthographic views, so that the size and shape of the component is fully understood. **Part drawings** and **assembly drawings** belong to this classification. An example of a machine drawing

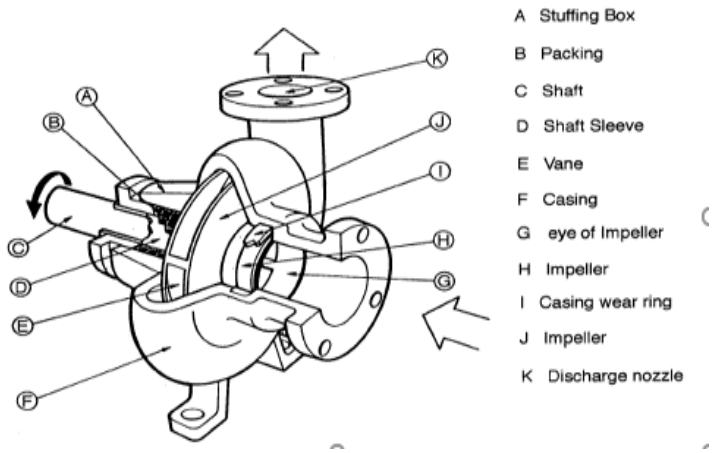


Fig 1.1 Example of machine drawing for centrifugal pump

4.2.2 Production drawing (working Drawing)

These types of Drawing furnish (show) all the dimensions, limits and special finishing processes such as heat treatment, honing, lapping, surface finish, etc., to guide the craftsman on the shop floor in producing the component. The title should also mention the material used for the product, number of parts required for the assembled unit, etc.

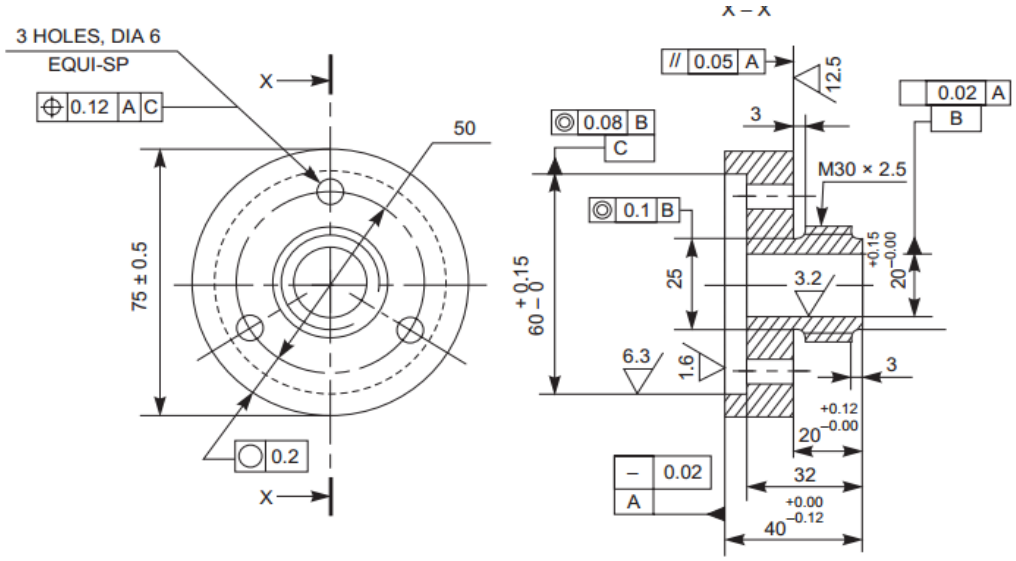


Fig 4.2 example of production drawing

4.2.3 Assembly drawing

A drawing that shows the various parts of a machine in their correct working locations is an assembly drawing (Fig. 4.3). There are several types of such drawings.

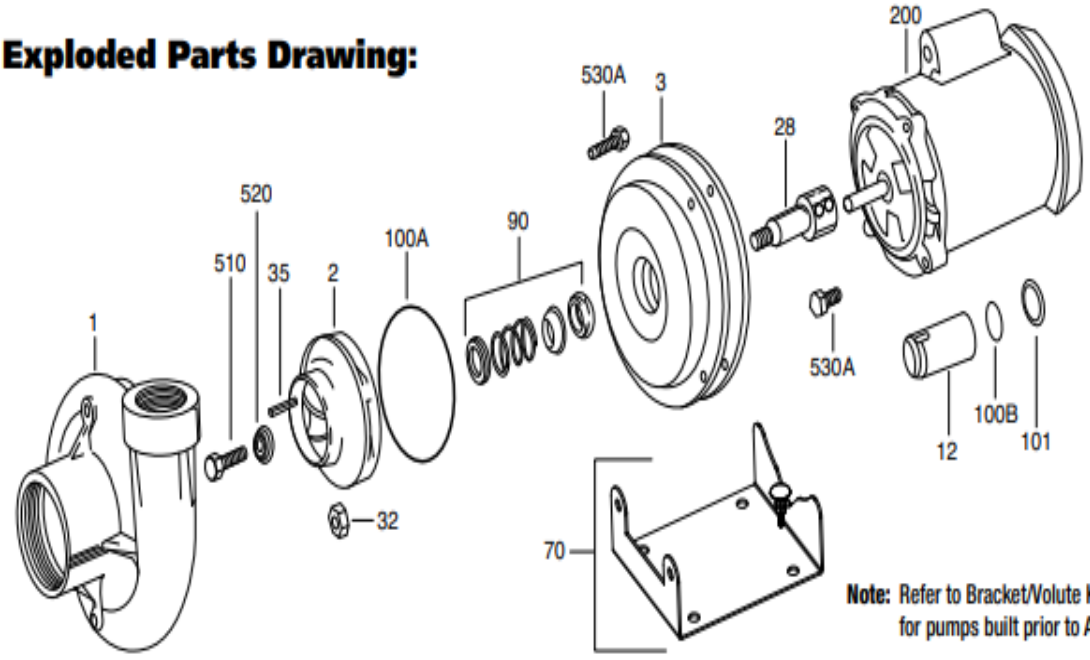
- **sub-assembly drawing:** A sub-assembly drawing is an assembly drawing of a group of related parts, that form a part in a more complicated machine. Examples of such drawings are: lathe tail-stock, diesel engine fuel pump, carburetor, etc.
- **assembly drawings for installation:**

  On this drawing, the location and dimensions of few important parts and overall dimensions of the assembled unit are indicated. This drawing provides useful information for assembling the machine, as this drawing reveals all parts of a machine in their correct working position.
- **assembly drawings for instruction manual**

  These drawings in the form of assembly drawings, are to be used when a machine, shipped away in assembled condition, is knocked down in order to check all the parts before reassembly and installation (maintenance) elsewhere.
- **Exploded assembly drawings:** In some cases, exploded pictorial views are supplied to meet instruction manual requirements.

  These drawings generally find a place in the parts list section of a company instruction manual. Figure 4.5 shows drawings of this type which may be easily understood even by those with less experience in the reading of drawings; because in these exploded views, the parts are positioned in the sequence of assembly, but separated from each other.

Exploded Parts Drawing:



Note: Refer to Bracket/Volute Kits page 15 for pumps built prior to August 2008

Materials and Parts: 3/4 - 3 hp with 56C Motor

Fig. No.	Part Description	Repair No.	Materials of Construction
1	Volute Case (NPT) w/plugs	305448001	Cast Iron, ASTM-A48 CL30
2	1hp Impeller Trim 3.94" (9/16-18 Thd)	305448021	Silicon Brass, ASTM B584
2	1-1/2hp Impeller Trim 4.31" (9/16-18 Thd)	305448022	Silicon Brass, ASTM B584
2	2hp Impeller Trim 4.59" (9/16-18 Thd)	305448023	Silicon Brass, ASTM B584
2	3hp Impeller Trim 5.12" (9/16-18 Thd)	305448024	Silicon Brass, ASTM B584
2	1800 RPM Pump End Kits Impeller Trim 6.44" max. (9/16-18 Thd)*	305447025	Silicon Brass, ASTM B584
3	Motor Backet	305447021	Cast Iron, ASTM-A48 CL30
28	Coupling (includes set screws)	305447022	DDA 360 Brass or 304 Stainless Steel
32	Impeller Jam Nut	305447023	18-8 Stainless steel
70	Base Assembly	305447024	Various
90	Mechanical Shaft Seal	305463203	Carbon/Ceramic/Buna/316SS
100A	Volute Case O-Ring (2-pack)	305463004	Nitrile
200	Motor	See Motor Section	
Not Shown	Pipe Plug (4-pack)	305463009	Cad-Plated Steel
530A	Motor Bracket Hex Cap Screw (4-Pack)	305463030	Zinc Plated Steel
530B	Volute Case Hex Cap Screw (4-Pack)	305463030	Zinc Plated Steel

Notes: Max O.D. impeller supplied with repair kits. Impeller must be trimmed to match motor hp.
Consult catalog for specific trim sizes and performance. Impellers should be rebalanced after trimming.

Fig 4.5 Exploded assembly drawings for centrifugal pump

- **Sectional view drawing:** which may importantly draw view on maintain mechanical generator. so, you have to understand what is sectional view?

  Interior features of an object can be described with the use of hidden lines. This can be become confusing however. The use of sectional views simplifies the representation of internal features. In a sectional view we imagine the object is cut by a plane to reveal the interior features.

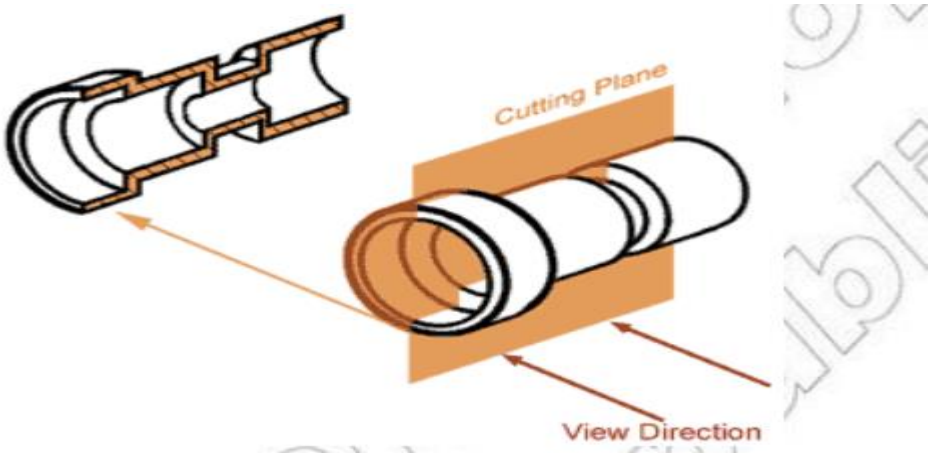


Fig 4.6 example of how objects cut on a cutting plan and see the sectional view

Self-Check -4	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided: and each contains 2pts

1. A drawing that shows the various parts of a machine in their correct working locations is

   A. Part drawing C. detail drawing

   B. assembly drawing D. Multiview drawing

2. Which type of drawing easily understood even by those with less experience in the reading of drawings;

   A. exploded drawing C. detail drawing

   B. assembly drawing D. Multiview drawing

3. Drawing is a suitable graphic language from which any trained person can visualize the required object.

   A. True B. False

4. Drawing displays the exact picture of an object; it obviously conveys the same ideas to every trained eye.

   A. True B. False

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

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3. _____4. _____

Information Sheet-5	**Determining, obtaining and inspecting the size, type and quantity of component**

5.1 Introduction to pump

- Pump is a mechanical device which raises the energy levels of various fluids by converting kinetic energy imparted by its prime movers into hydraulic energy.
- Pump is a machine to transport the liquid from one place to another place usually through a pipe.
- A pump may, therefore, be defined as “a mechanical device which converts the mechanical energy imparted to it from an external source (electric motor, diesel engine or even manual energy) into hydraulic energy in the fluid handled by it”.
- As a consequence, the energy level of fluid handled by the pump or flowing through the pump is augmented, making it possible for the fluid to move from a lower level to a higher level, against gravity and friction.

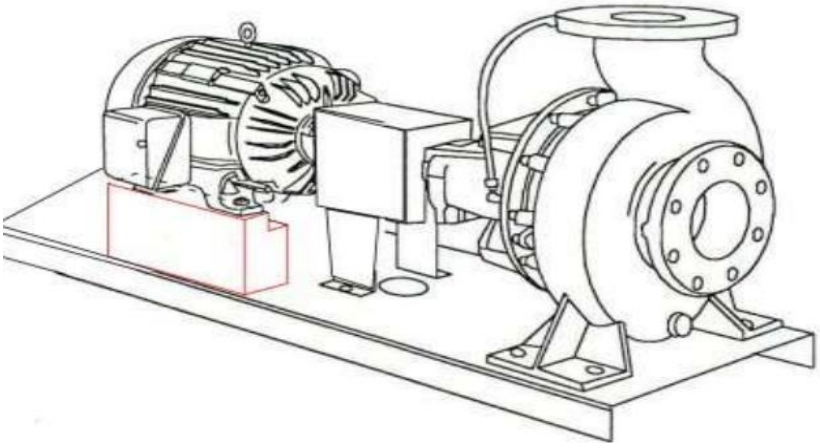


Fig 5.1 Centrifugal pump with motor

5.2 Applications of pump

The following are a few main domains that use pumps extensively:

- **Water Supply**– To supply water to inhabited areas.
- **Drainage**– To control the level of water in a protected area.

- **Sewage**– To collect and treat sewage.
- **Irrigation**– To make dry lands agriculturally productive.
- **Chemical Industry**– To transport fluids to and from various sites in the chemical plant.
- **Petroleum Industry**– Used in every phase of petroleum production, transportation, and refinery.
- **Pharmaceutical and Medical Field**– To transfer of chemicals in drug manufacture; pump fluids in and out of the body.
- **Steel Mills**– To transport cooling water.
- **Construction–** Bypass pumping, well-point dewatering, remediation, general site pumping applications.
- **Mining–** Heavy-duty construction, wash water, pumping of dust control fines and tailings, site dewatering, groundwater control and water runoff.

Pumps are also used for diverse applications ranging from transfer of potatoes to peeling the skin of hazelnuts in chocolate manufacture, and to cut metal sheets in areas that are too hazardous to cut by a gas flame torch. The artificial heart is also a mechanical pump. The heart-lung machines used during open heart surgeries perform the function of the heart using roller pumps.

5.2 Types of Pumps

The family of pumps comprehends a large number of types based on application and capabilities.

Pumps can be classified in various ways. Pumps based on their principle of operation are primarily classified into:

- Positive displacement pumps (reciprocating, plunger type of pumps)
- Roto-dynamic pumps (Centrifugal pumps)
- Other pumps

5.2.1. Kinetic (dynamic):

These type of raise the pressure of a liquid by imparting velocity energy to it, and then converting it to pressure energy.

a. Axial Pump: In these flow pumps, the entry and exit are parallel to the axis of the impeller
b. Centrifugal (Radial) Pump: In these flow pumps, the exit is perpendicular to the flow at the inlet
c. Mixed Flow Pump: In mixed flow pumps, the flow at the exit of the impeller is at an angle to the axis of the impeller.

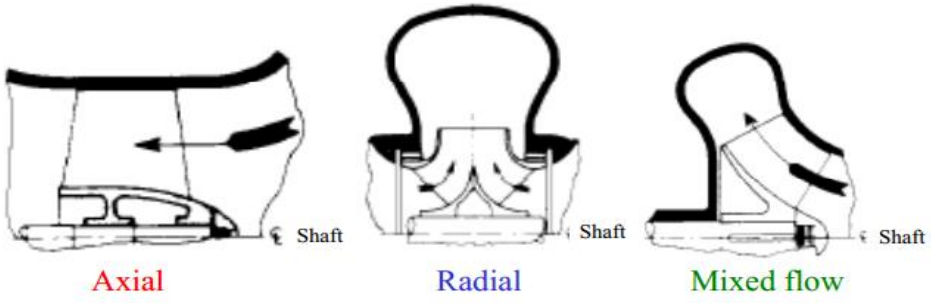


Fig. 5.2 kinetic pumps

5.2.2 Positive Displacement

Positive displacement pumps, which lift a given volume of the fluid for each cycle of operation, can be divided into two main classes**, Reciprocating and Rotary**. Reciprocating pumps include piston, plunger, and diaphragm types. Rotary pumps include gear, lobe, screw, vane, peripheral and progressive cavity pumps.

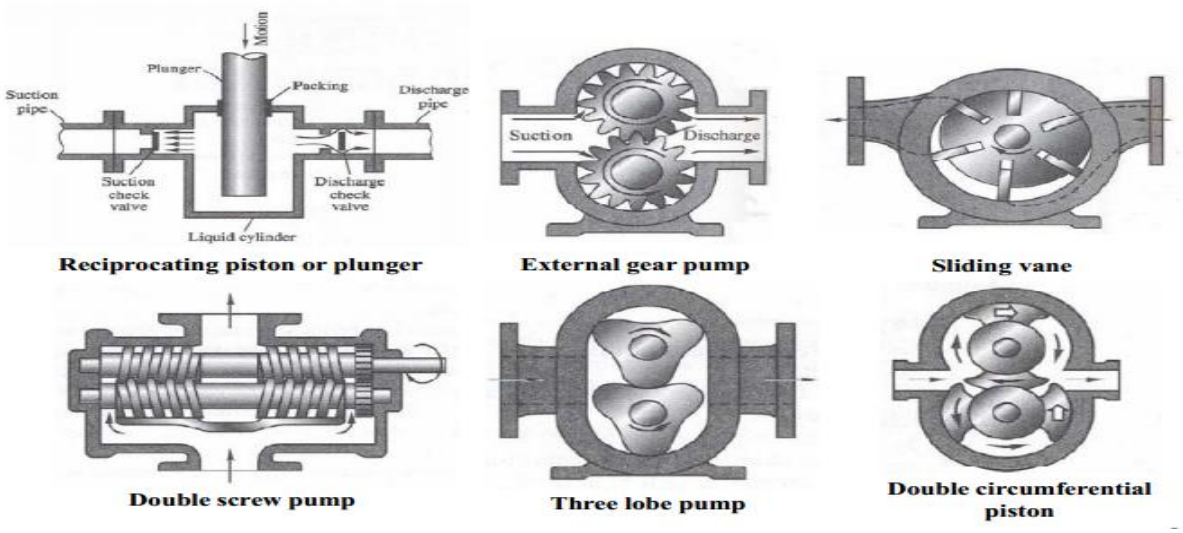


Fig 5.3 Positive Displacement Pump types

What is the deference between positive displacement pump and kinetic pump? Kinetic Pumps generators **Head** but Positive Displacement Pumps generator flow

5.2.3. Other types of pumps

Many other types of pumps exist, including electromagnetic pumps, jet pumps, hydraulic ram pumps, hand pump and rope pumps

In this module we will see detail **centrifugal pumps** /surface pump, submersible pump/and **lift pumps** /hand pump and rope pumps/ which are commonly used for water supplying purpose in our country

5.3 Centrifugal Pumps

- Centrifugal, (Sen-trif"-u-gal) which means: Tending to fly from a center or Thrown from a center.
- A centrifugal pump is one of the simplest pumps. Its purpose is to convert energy of a prime mover (an electric motor, or engine drive) first into velocity or kinetic energy and then into pressure energy of a fluid (water) that is being pumped.
- Centrifugal pump impeller does just that water drawn into impeller eye, accelerated down the blades and thrown against pump casing that directs flow out of discharge.

- Convert the mechanical energy into hydraulic energy by centrifugal force on the liquid.
- Constitute the most common type of pumping machinery. Used to move liquids through a piping system.

5.3.1 Constructional features of centrifugal pump (surface pump & submersible pump)

A centrifugal pump has two main components:

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

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

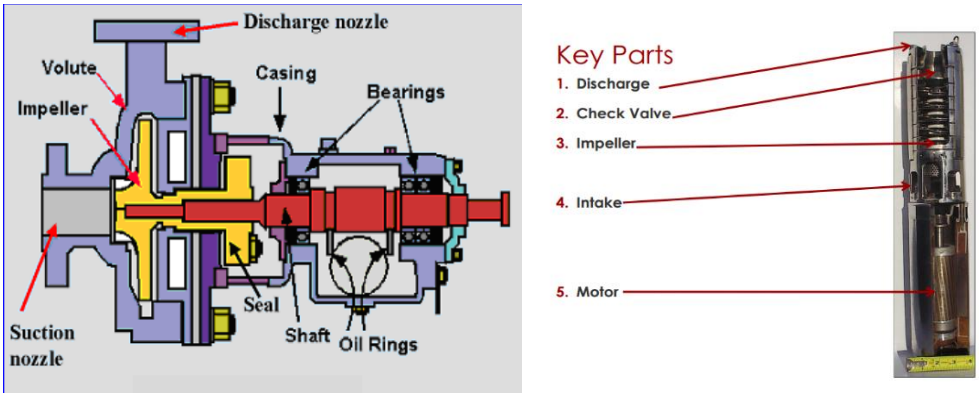


Fig.5.4 key parts of pump

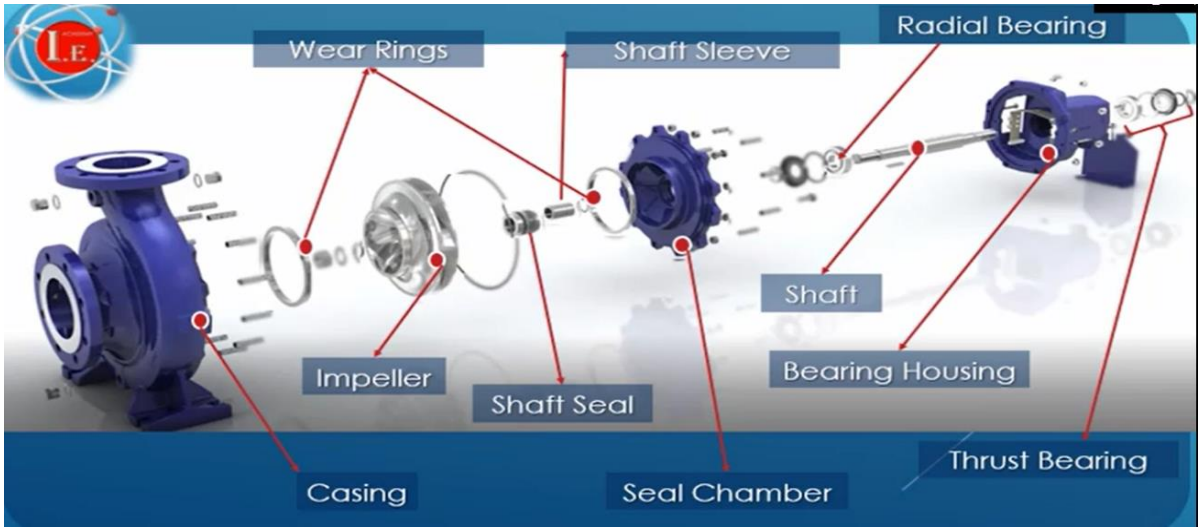


Fig 5.5 Centrifugal pump (for surface pump) – basic construction

(For more see https://youtu.be/XpcCUtYzwy0 and https://youtu.be/L0Q6cboXyLY)

- **Bed plate**

This may be of cast iron or welded steel construction but should be perfectly rigid. It should be bolted to the foundation at a number of points all round. Dowel locating pins are driven through the pump and motor legs right into the bed plate to ensure easy assembly and correct alignment

- **Pump casing**

This is usually made of close-grained cast iron. It may be split in the vertical plane at the center of the casing and the two halves held together by a number of bolts and one or two locating pins.

To facilitate dismantling of the impeller an end cover is usually provided. Alternatively, the casing may be split horizontally to enable easy removal of the entire impeller and spindle without the necessity of breaking any pipe joints, as all pipe connections are made at the bottom half of the casing.

In general type of casing are „Volute" and Diffusion.

- Volute Casing
- Volute Casing is the one most commonly used.
- Impeller discharges into a progressively expanding spiral casing.
- Casing is proportioned to produce equal velocity flow all around its circumference.
- Reduce the velocity of the liquid.
- It flows impeller to discharge.
- Changing velocity head into pressure head.

Impeller

This is usually of close-grained cast iron or cast steel, hydraulically and dynamically balanced to avoid end-thrust and vibration. To eliminate possibility of rusting, impellers are frequently made of gun-metal.

- Main rotating part that provides centrifugal acceleration to the fluid.
- Number of impellers = number of pump stages

- Impeller classification: direction of flow, suction type and shape/mechanical construction.

Enclosed Impeller Semi open impeller

Open impeller

Fig 5.4 types of impeller

- **Shaft**

Transfers torque from motor to impeller during pump start up and operation.

- **Spindle**

This is of steel of ample proportions. Where corrosive liquids are to be handled, stainless steel spindles may be fitted. To ensure central alignment of the impeller with respect to the casing, thrust collars are usually fitted. The portion of the spindle which works inside the stuffing box is usually fitted with a renewable gunmetal sleeve so that it may be replaced when it gets worn out and the spindle may have a long time.

Similarly, renewable bronze neck-rings are often fitted in a good make of pump on the bearing surfaces of the impeller and pump casing. This permit working clearances being reduced greatly, thereby reducing the loss of efficiency due to leakage from the delivery to the suction side of the pump.

- **Stuffing box and gland packing**

This serves two purposes: on the suction side it prevents leakage of air and on the delivery side leakage of water under pressure. The packing material consists of rings of soft, cotton,

woven yarn, impregnated with graphite and tallow. The gland bolts should only be tightened lightly, just enough to prevent leakage.

Indeed, a slight seepage (10 to 20 drops per min) is a good sign of the bearing not running dry and keeping cool. Over tightening should be avoided as it will tend to grip the spindle, making it hot and perhaps overloading the motor.

- **Shaft seal**

Modern pumps are often fitted with mechanical leak-proof seals. Basically, it consists of a mirror-finished, hard, flat surface against which bears a spring-loaded ring of a softer material like carbon, rubber, leather, or plastic. The combination permits free rotation without permitting any leakage. The **seal** is kept cool by the liquid pumped.

- **Bearings**

These may be of the ball, roller or sleeve type. Grease lubricators are provided on the bearing housing. In vertical bore-hole type pumps some form of thrust bearing employing water lubrication, like the Mitchell thrust bearing is employed. This comprises a number of pivoted pressure pads of soft material like gunmetal, bearing against a hard, rotating, polished surface. The arrangement is such that a wedge of lubricant (water or oil) is formed between the surfaces, which ensure perfect lubrication, so essential in thrust bearings

5.3.2 Centrifugal Pumps working principle:

The prime mover, which is usually an electrical motor, steam turbine or an IC engine, transmits the torque through the coupling.

As the impeller rotates, it accelerates and displaces the fluid within itself, and more fluid is drawn into the impeller to take its place if the pump is properly primed. Thus, **the impeller** imparts kinetic or velocity energy to the fluid through mechanical action. This velocity energy is then converted to pressure energy by **the volute**. The water then passes through a volute chamber surrounding the impeller, whose cross-section progressively increases towards delivery side so that the high velocity is converted into pressure head smoothly without turbulence or shock.

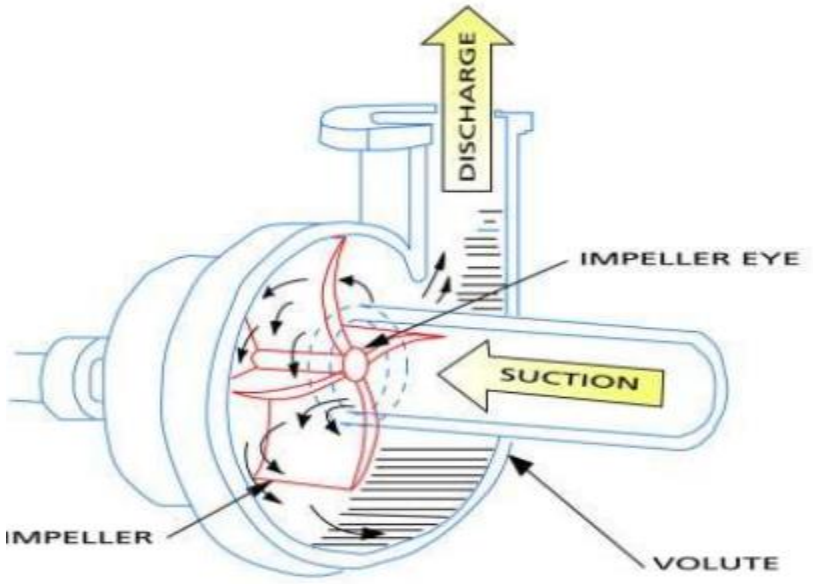


Fig 5.5 Working centrifugal pump

Water Flow Stages

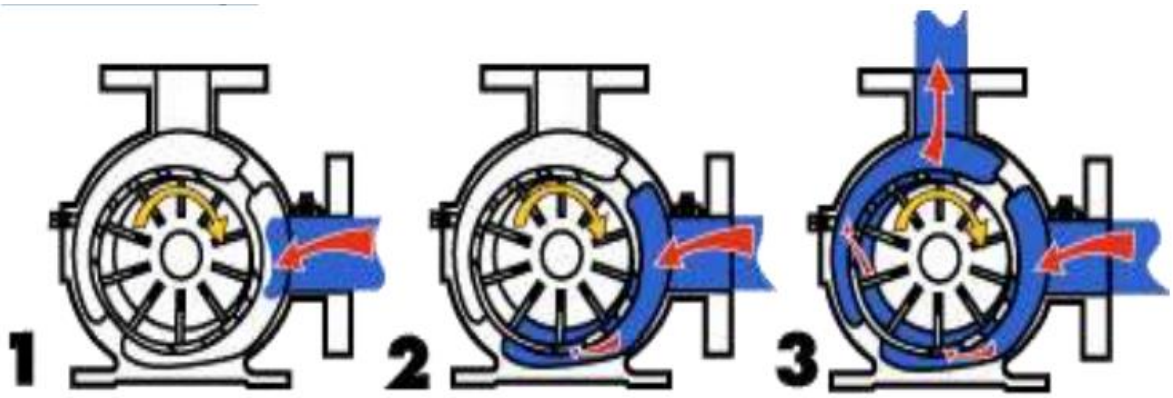


Fig5.6 Water Flow Stages

Liquid forced into impeller.

- Vanes pass kinetic energy to liquid; liquid rotates and leaves impeller.
- Volute casing converts kinetic energy into pressure energy

5.3 Pump standards

A number of centrifugal pump standards have been developed to bring about uniformity and minimum standards of design and dimensional specifications. These include the API (American Petroleum Institute), ISO (International Standards Organization), ANSI (American National Standards Institute), DIN (German), NFPA (Nation Fire Protection Agency), and AS-NZ (Australia–New Zealand).

Some of the most common standards, which are used in the development and manufacture of centrifugal pumps are API-610, ISO-5199, 2858, ANSI B73.1, DIN 24256, NFPA-21.

Fig 5.12 Pump built to API-610 standard

5.4. pump size and Selection

5.4.1 pump rating

- The manufacturer will rate the pump at its optimum total head and flow, this point is also known as the best efficiency point or B.E.P. At that flow rate, the pump is at its most efficient and there will be minimal amount of vibration and noise.
- Of course, the pump can operate at other flow rates, higher or lower than the rating but the life of the pump will suffer if you operate too far away from its normal rating.
- Therefore, as a guideline aim for a maximum variation of plus or minus 15% on total head.

5.4.2 Relationship between head, quantity, speed and power

- **Variation of Impeller Diameter (with speed remaining constant)**
  - ✓ Capacity varies directly proportionate to diameter.
  - ✓ Head varies proportionate to square of the diameter.

- ✓ BHP varies proportionate to cube of the diameter

- **Variation of Speed (with impeller, diameter remaining constant)**
  - ✓ Capacity varies directly proportionate to speed.
  - ✓ Head varies proportionate to square of the speed.
  - ✓ BHP varies proportionate to cube of the speed.

5.4.2 centrifugal Submersible Pump Sizing & Selection

Fig 5.13 Submersible Pump in different size

- **Pump Parameters**

A. Flow rate & the amount of lift required.

1.Flow Rate: Make sure the aquifer is capable of supporting your desired flow rate.

2. Lift: Submersible pumps do not build pressure. They provide lift which overcomes head pressure, which is measured in feet.

The head pressure against which a submersible pump operates is referred to as **TOTAL DYNAMIC HEAD (TDH):**

- **Total Dynamic Head (TDH)** is the amount of head or pressure on the suction side of the pump (also called static lift), plus the total of 1) height that a fluid is to be pumped plus 2) friction loss caused by internal pipe roughness or corrosion.

TDH=Pumping Level + Vertical Rise(height that a fluid) **+ Friction Loss**

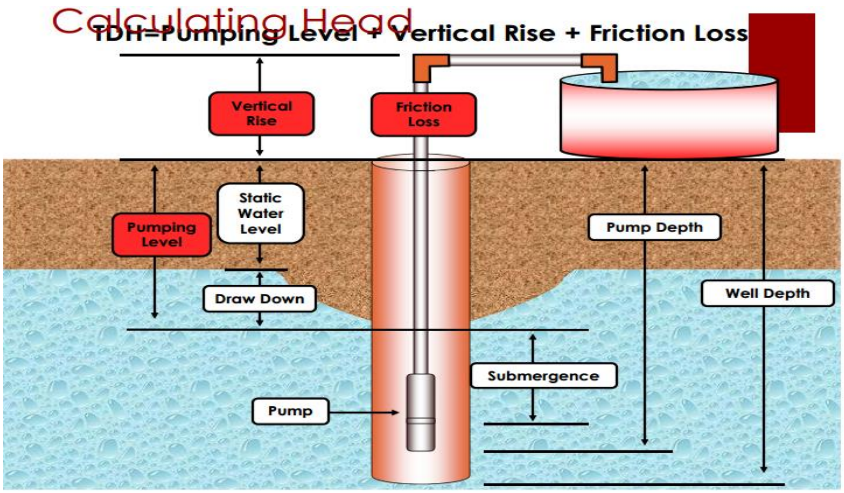


Fig 5.14 TDH calculation

- **We get frictional loss from table below**

Friction Loss Table – VALVES and FITTINGS

(Friction Loss in Equivalent Number of Feet of Straight Pipe)

TYPE OF FITTING AND APPLICATION	PIPE AND FITTING	NOMINAL SIZE OF FITTING AND PIPE						
		1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"
		EQUIVALENT LENGTH OF PIPE(IN FEET)						
Insert Coupling	Plastic	3	3	3	3	3	3	3
Threaded Adapter (Plastic to Thread)	Plastic	3	3	3	3	3	3	3
90° Standard Elbow	Steel	2	2	3	4	4	5	6
	Plastic	2	2	3	4	4	5	6
Standard Tee (Flow Through Run)	Steel	1	2	2	3	3	4	4
	Plastic	1	2	2	3	3	4	4
Standard Tee (Flow Through Side)	Steel	4	5	6	7	8	11	13
	Plastic	4	5	6	7	8	11	13
Gate Valve[1]	Steel	1	1	1	1	2	2	2
Swing Check Valve[1]	Steel	5	7	9	12	13	17	21

Friction Loss Table – VALVES and FITTINGS

(Friction Loss in Equivalent Number of Feet of Straight Pipe)

TYPE OF FITTING AND APPLICATION	PIPE AND FITTING	NOMINAL SIZE OF FITTING AND PIPE						
		1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"
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Insert Coupling	Plastic	3	3	3	3	3	3	3
Threaded Adapter (Plastic to Thread)	Plastic	3	3	3	3	3	3	3
90° Standard Elbow	Steel	2	2	3	4	4	5	6
	Plastic	2	2	3	4	4	5	6
Standard Tee (Flow Through Run)	Steel	1	2	2	3	3	4	4
	Plastic	1	2	2	3	3	4	4
Standard Tee (Flow Through Side)	Steel	4	5	6	7	8	11	13
	Plastic	4	5	6	7	8	11	13
Gate Valve[1]	Steel	1	1	1	1	2	2	2
Swing Check Valve[1]	Steel	5	7	9	12	13	17	21

To get flow rate we to pump curve;

- **Pump curve**

Curves typically include performance metrics based on pressure, flow, horsepower, impeller trim, and Net Positive Suction Head Required (NPSHr). Pump curves are useful because they show pump performance metrics based on head (pressure) produced by the pump and water-flow through the pump. Flow rates depend on pump speed, impeller

diameter, and head. (https://www.csidesigns.com/blog/articles/how-to-read-a-pump-curve)

Sample

What is required/desired flow? 5 GP

Determine TDH

First, let's calculate friction loss!

Friction loss = total length X friction loss (straight pipe) factor + friction loss (fittings)

Friction loss = (922' X 1.8'/ 100') + (3 ' X 2) (1.8'/100')

Friction loss = 16.60' + .108'

Friction loss = 17' Head Pressure

Now we can calculate TDH!

TDH = pumping level + vertical rise + friction loss

TDH = 500' + 222' + 17'

TDH = 739'

Now that we know the TDH and required/desired flow, we can select a pump from a performance

curve.

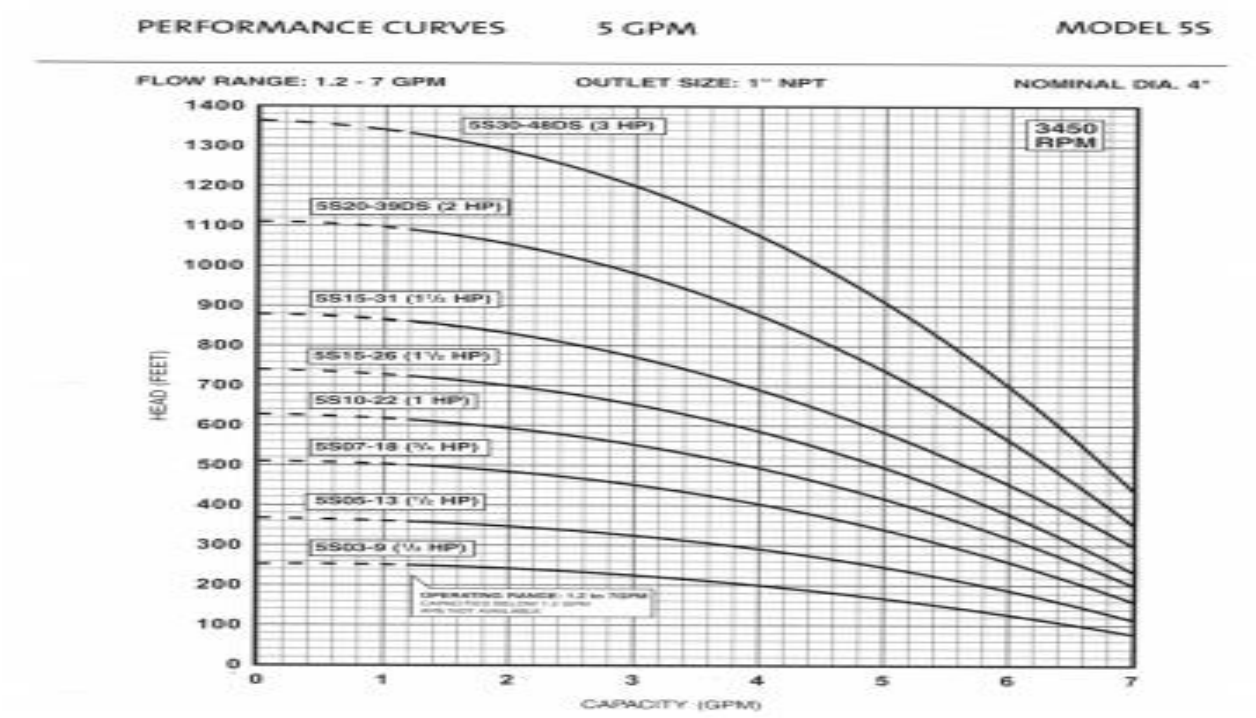


Fig 5.15 Typical performance curves for a centrifugal pump

5.4.3 Pump Performance Curves and Similarity Rules

Performance charts are almost always plotted for constant shaft-rotation speed n (in r/min usually). The basic independent variable is taken to be discharge Q (in gal/min usually for liquids and ft^3/min for gases). The dependent variables, or "output,'' are taken to be head H (pressure rise Δp for gases), brake horsepower (bhp), and efficiency η.

Figure 5.15 shows typical performance curves for a centrifugal pump. The head is approximately constant at low discharge and then drops to zero at Qmax. At this speed and impeller size, the pump cannot deliver any more fluid than Qmax. The positive-slope part of the head is shown dashed; as mentioned earlier, this region can be unstable and can cause hunting for the operating point.

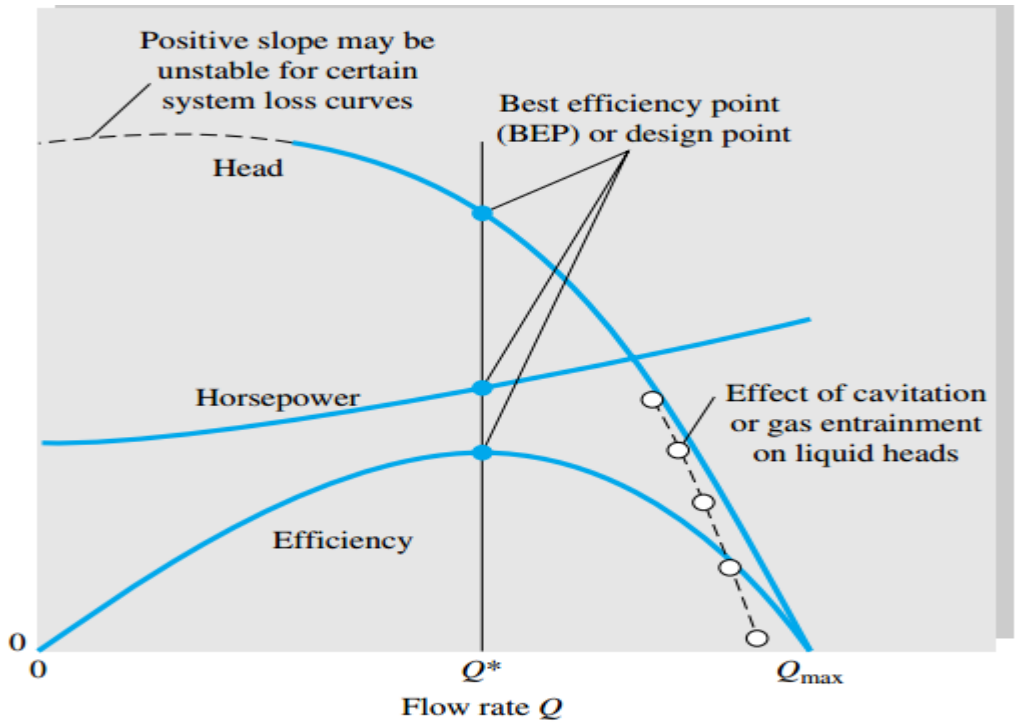


Fig 5.16Typical centrifugal pump performance curves at constant impeller-rotation speed.

5.5 PUMP DRIVES

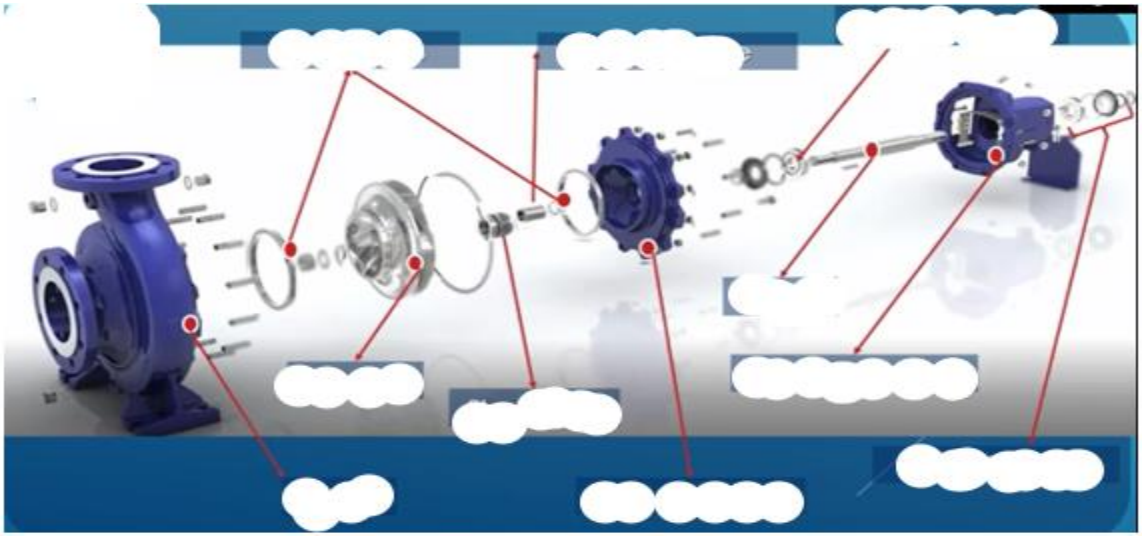
Pump drives for water supply and distribution pumps will be electric motors. Diesel or other fuels will be considered as a power source only for emergency use. The drivers will be constant speed AC motors of the squirrel-cage induction, wound rotor or synchronous type.

5.5.1 MOTORS.

Motors will be selected with sufficient capacity to drive the pumps under service required without exceeding 85 percent of the specified rating.

Self-Check -5	Written Test

Directions1. Write down the parts of centrifugal (surface pump) pump components shown in the figure below. It contains 4pts



Directions2. Write down the parts of centrifugal (submersible pump) pump components shown in the figure below. It contains 4pts

Directions3. Marching the impeller shown in column A with their name listed in column B 2ponts for each.

A		B
1.		A. open impeller
2.		B. closed impeller
3.		C. mixed impeller
		D. semi -open impeller

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

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3. _____

Information Sheet-6	**Planning Work in detail including sequencing and prioritizing and considerations**

6.1 Development of maintenance plans

The Maintenance Procedure Manual should stipulate the following;

- Maintenance plan is prepared yearly based on approved maintenance procedure manual
- Responsibility of facility owners or authorized persons for preparing and approving the maintenance plan.
- The maintenance plan can be revised, supplemented during implementation process. Information to be stated in the maintenance plans
  - ✓ Name of activities to be undertaken;
  - ✓ Implementation time duration;
  - ✓ Implementation method;
  - ✓ Implementation expenses.

6.2 The steps in maintenance will include, at a minimum:

- Periodic review of a schedule to determine what tasks should be conducted on a system.
- Regular review of expendable items to ensure sufficient supplies are on hand or ordered.
- Issuing work orders or scheduling tasks to accomplish maintenance.
- Review of the completed task.
- Modification of the preventive maintenance (PM) schedule, if necessary.
- Budget management.

Self-Check -6	Written Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided: and each contains 2pts

1. Maintenance plan is prepared yearly based on approved maintenance procedure manual

   A. True B. False

2. The maintenance plan can be revised, supplemented during implementation process.

   A. True B. False

3. which of the following is information that stated in the maintenance plans

   A. Implementation time duration B. Implementation method;

   C. Implementation expenses. D. All

D. semi -open impeller

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 3 points**

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3. _____

Information Sheet-7	**Resolving the Coordination requirements that affected by the work**

7.1 Introduction to resolving the Coordination requirements

Workers performing service or maintenance on machinery and equipment (e.g. when install pump) may be exposed to injuries from the unexpected energization, startup of the machinery or equipment, or release of stored energy in the equipment. To reduce these injure we have to followed some solation procedures.

7.2. Isolation procedures

To reduce these injure we have to followed some resolving or isolation mechanisms

7.2.1 Lockout and tag out

These procedures used to safeguard workers from the unexpected startup or release of stored energy during service or maintenance activities like

- Lubricating
- Cleaning
- Unjamming machines and equipment

They prevent machines or equipment from becoming energized because they are positive restraints that no one can remove without a key or other unlocking mechanism

Lockout is when a lockout device is applied to equipment and machinery before working on equipment.

Lockout devices hold energy isolating devices in a safe or “OFF” position

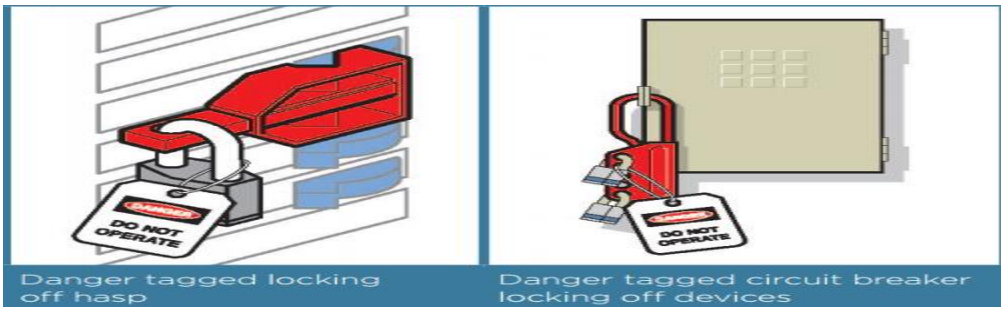


Fig. 7.1 machine/equipment in lockout

- **Tagout** is warning devices that authorized workers fasten to energy isolating devices to warn other workers not to start the machine while it is being serviced or undergoing maintenance.
- **Tagout devices** are easier to remove and provide less protection than lockout devices.

Fig 7.2 Tagout devices

- When both lockout and tagout are used, it is known as LOTO

Fig 7.3 machine in LOTO

When both lockout and tagout are used, it is known as **LOTO**. There are three levels of LOTO training

- **Authorized worker:** lock out and tag out machines or equipment to perform servicing and maintenance

Fig 7.4 Authorized worker lock out the machine

- **Affected worker:** operate and use machines or equipment that is under LOTO**, t**hey do not perform LOTO or service and maintenance on machines or equipment.

Fig 7.5 Affected worker do not perform LOTO or service and maintenance on machines

- **Other worker:** may be in the area where LOTO procedures are happening.

  They are informed about

  - The LOTO procedures,
  - Equipment that is being serviced or undergoing maintenance
  - Locks or tags put into place to prevent the startup of the machine or equipment and tagout are used on pump, so the pump is in **LOTO.**

Blank Form

Lockout/Tagout Machine Specific Procedure

Equipment or Process:_____

Location of Equipment: _____

A tag is required on each **Isolation Location** listed below
The Specific **Type of Lock** must be applied at the location listed

Date prepared _____ **Prepared by** _____

Type of Energy	Isolation Location	Type of Lockout Device
Electrical		
Potential (Stored)		
Kinetic (in-motion)		
Pneumatic (air - gas pressure)		
Hydraulic		
Thermal		
Chemical		

Special Hazards	Procedure for Control of Special Hazard

Special Procedures

Stored Energy Release Procedure

Notes
Isolation Location shall positively identify the exact breaker, valve, switch or other disconnect or blocking device to be locked and tagged to isolate the source of energy from the work area.
Type of Lockout shall specifically name the exact type of locking device needed to ensure the disconnect or blocking device stays in the isolated condition/position. i.e.. Breaker Clip, Valve Handwheel Cover, Blank Flange, etc.
Stored Energy: Following the application of the lockout or tagout devices to the energy isolating devices, all potential or residual energy will be relieved, disconnected, restrained, and otherwise rendered safe.

Fig 7.6 sample for tagout form to isolate a pump for maintenance

Self-Check -7	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1._____ procedures should be used to safeguard workers from the unexpected startup or release of stored energy during service or maintenance activities.

A. Stop work B. Lockout and tagout C. Confined space D. Energization

2. _____ are warning devices that let other workers know not to start the machine while it is being serviced or undergoing maintenance.

A. Locks B. Signs C. Tags D. Energy isolating devices

3. _____ are positive restraints that no one can remove without a key or other unlocking.

A. Lockout devices B. Warning tags C. Product labels D. Energy isolating

4. When both lockout and tagout are used, it is known as _____.

A. OSHA B. NFPA C. LOTO D. ANSI

5. ___workers lock out and tag out machines or equipment to perform servicing and maintenance.

A. Other B. Authorized C. Affected D. Unqualified

6. _____ workers operate and use machines or equipment that is under LOTO, but do not perform LOTO or service and maintenance on machines or equipment.

A. Other B. Affected C. Authorized D. Unqualified

7. _____ workers may be in the area where LOTO procedures are happening.

A. Other B. Affected C. Authorized D. Unqualified

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

Answer Sheet-6

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3. _____ 4. ____5 _____6 _____7 _____

Information Sheet-8	**Identifying and preventing Potential hazards and selecting control measures**

8.1 Introduction to Potential hazards

Potential hazards include, but are not limited to, high temperature, flammable, acidic, caustic, explosive, and other **risks**.

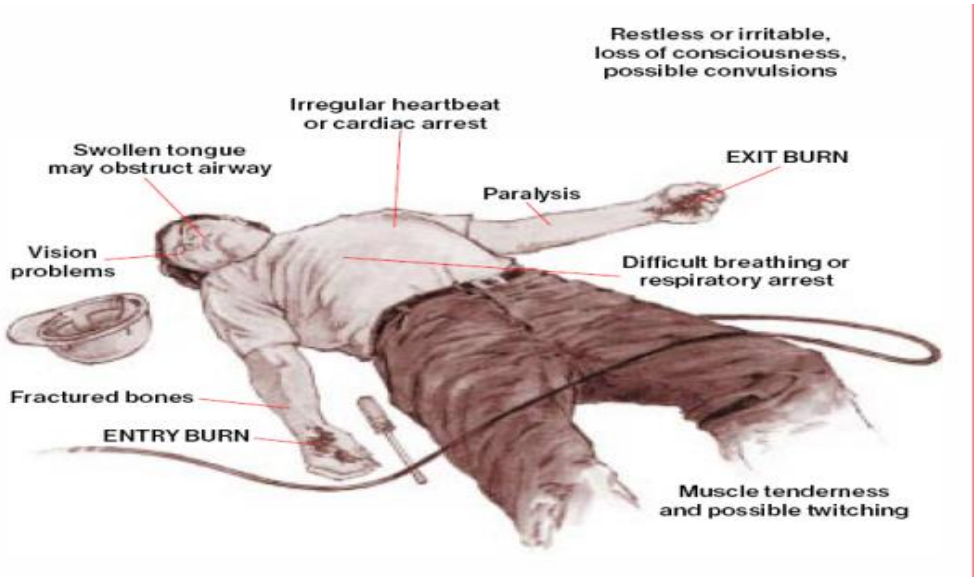


Fig 8.1 Worker suffer With an Electrical Injury(hazard)

Types of hazards are:

Biological hazard. Biological hazards include viruses, bacteria, insects, animals, etc., that can cause adverse health impacts. For example, mould, blood and other bodily fluids, harmful plants, sewage, dust and vermin.

Chemical hazard. Chemical hazards are hazardous substances that can cause harm. These hazards can result in both health and physical impacts, such as skin irritation, respiratory system irritation, blindness, corrosion and explosions.

Physical hazard. Physical hazards are environmental factors that can harm an employee without necessarily touching them, including heights, noise, radiation and pressure.

Ergonomic hazard. Ergonomic hazards are a result of physical factors that can result in musculoskeletal injuries. For example, a poor workstation setup in an office, poor posture and manual handling.

Psychosocial hazard. Psychosocial hazards include those that can have an adverse effect on an employee's mental health or wellbeing. For example, sexual harassment, victimization, stress and workplace violence.

8.2 Hazard in pump work

Pumps are one of the most ubiquitous items of equipment found in chemical processing plants. Often, they are used to transfer hazardous liquids, such as flammable, combustible, toxic and corrosive chemicals.

A number of problems and hazards can occur during the pumping of liquids. These can include the following:

- Mechanical seal failures resulting in leaks or fugitive emissions
- Reduced or low flow in centrifugal pumps
- Over pressurization
- High temperature

General recommendations to reduce hazards related to pump work are;

1. **Materials of construction:** Materials of construction should be chosen based on the corrosive properties of the liquid being pumped. At a minimum, pumps should be constructed of cast steel. All the components of the pump (casing, impeller, mechanical seal or packing and other trim) should be compatible with the liquid being pumped. Cast iron should not be used for hazardous liquids, at pressures above 200 psig or temperatures above 175°C. Cast iron is brittle and can be cracked by mechanical or thermal shock, which could result in leaks and subsequent fires. Ductile iron is also

appropriate for some applications, but it should be noted that ductile iron, when exposed to high temperatures produced by fires, can revert to cast iron, and should be avoided if there is any risk of fire.

2. **Pump location:** Pumps should be installed and located in a way that facilitates safe maintenance. When they are intended to handle hazardous liquids such as toxic, pyrophoric or water-reactive liquids, pumps should not be located beneath main-plant pipe racks. If a fire occurs at the pump, flames could reach the piping above and over pressurize the fluid contained in the piping or stress and weaken the piping due to heat absorption.
3. **Backflow protection:** Backflow can occur in a pumping system when the motor (or another driver) is stopped, either intentionally or accidentally. Depending on what type of pump is used, this may result in the flow of the pumped liquid through the pump to the suction vessel and possible vessel overflow. It may also result in reverse rotation of a non-running installed spare pump, which could cause damage. To avoid or limit backflow, a check valve should be installed in the pump discharge line. For highly hazardous liquids, it may be desirable to install two check valves in series. Alternatively, a fast-acting open-shut valve, activated by a low-pressure sensor in the discharge line that will shut the valve tightly, can be used. When check valves or fast-acting open-shut valves are used in the discharge line of a pump, it may be necessary to establish a way to prevent hydraulic hammer.
4. **Other safety considerations**

- Provide warning lights on location for pumps that are remotely or automatically started
- Clearly identify pump shutdown and start-stop switches regardless of whether the switch is local or remote, and provide lockout capability at the pump driver or power source
- Provide a shaft-coupling guard for all pumps with exposed shafts
- Allow for the safe drainage of the pump casing and the suction and discharge piping for all pumps. Provide schedule 160 (or heavier, when necessary) casing drains and casing vents for pumps handling hazardous liquids.

- Monitor pump-bearing temperature with alarms and/or motor shutdown at high temperature. Lack of lubrication can result in high bearing temperature and possible failure, which in turn can lead to shaft misalignment and mechanical seal failure
- A temperature sensor should be installed in a pump casing if the pump is handling a temperature-sensitive liquid. The sensor should be interlocked to shut the motor off when the high-temperature limit of the liquid is reached
- Pumps handling flammable liquids should be properly bonded and grounded to prevent electrostatic ignitions
- The seal areas of pumps handling corrosive liquids may require spray shields for personnel protection

Self-Check -8	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1.Which of the following is cause for hazard?

A. high temperature B. flammable liquid

C. acidic substance D. all

2. Which of the is a type of hazards

A. Physical hazard B. Psychosocial hazard

C. Chemical hazard D. All

3. Which of the following is a recommendation to reduce hazard related to pump

A. select proper types materials for the construction of pump

B. Installed and located pumps in a way that facilitates safe maintenance

C. Provide a shaft-coupling guard for all pumps with exposed shafts

D.All

4. Pumps handling flammable liquids should be properly bonded and grounded to prevent electrostatic ignitions.

A. True B. False

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

Answer Sheet-6

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3. _____ 4. ___

Information Sheet-9	**Preparing work area in accordance with work requirements and site procedures**

9.1 Introduction to preparing work area for pump

Pumps, piping, and equipment must be protected from the weather as dictated by local climatic conditions. In cold climates pumps and piping must be protected from freezing and are usually completely housed in structures. In warm climates portions of stations may be located in outside enclosures which must provide protection from moisture and other weather-related conditions. The impact of noise on the surrounding area and the need for security fencing will be considered for all stations. Structures will be fire-resistive construction, usually of reinforced concrete, steel, and masonry wall construction. The pumping equipment must be located so as not to be subject to flooding. The site will be graded to drain surface water away from structures. Roadway access for maintenance vehicles will be provided at all equipment locations with space provided for vehicle turn around. Buildings will be designed in compliance with local codes and regulations. Building layouts must be designed logically considering the sequence of installation of initial and future equipment if future expansion is planned. Space will be provided for removing equipment for repair without interrupting other equipment. Equipment layouts must provide vertical and horizontal clearances and access openings for maintenance and repair operations. Usually, main aisles will be four feet minimum. Work place safety of operating and maintenance personnel and security of the facility will be considered in the overall pump station design.

Generally, pumps and its control boards protected from sunshine or rain or dust and is located in appropriate area that is free from any insecure item that could inhibit operation, ensure cooling air ventilation screen are clear

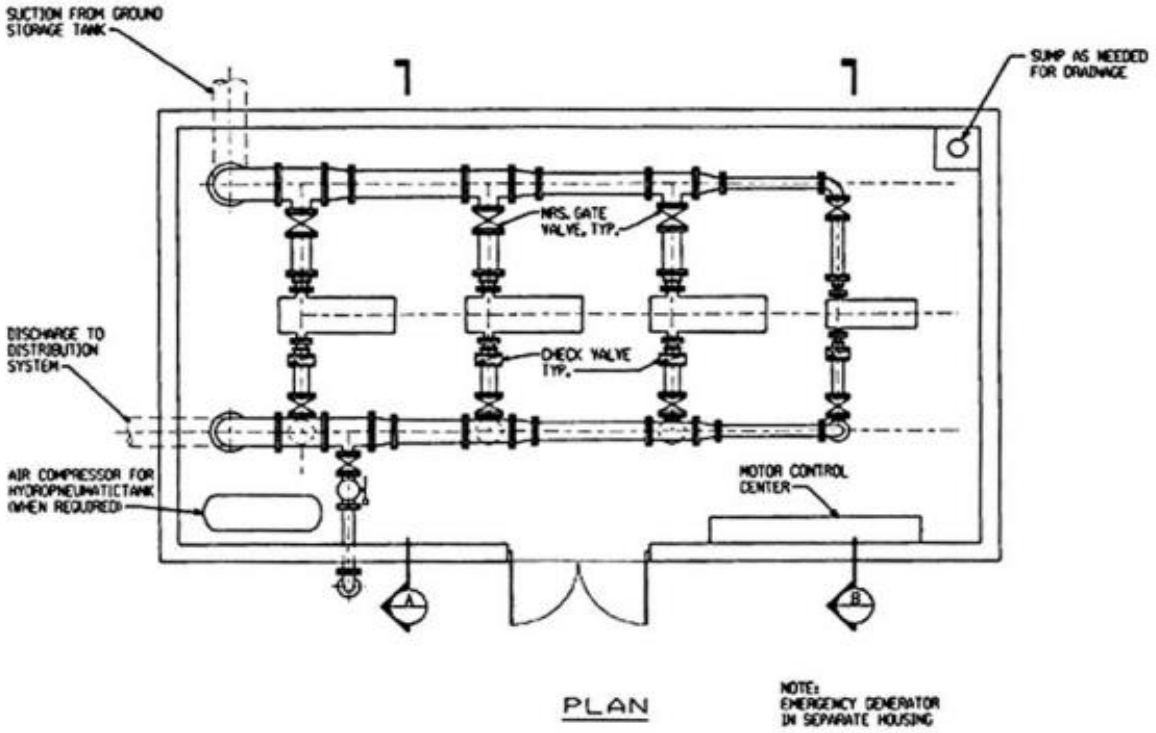
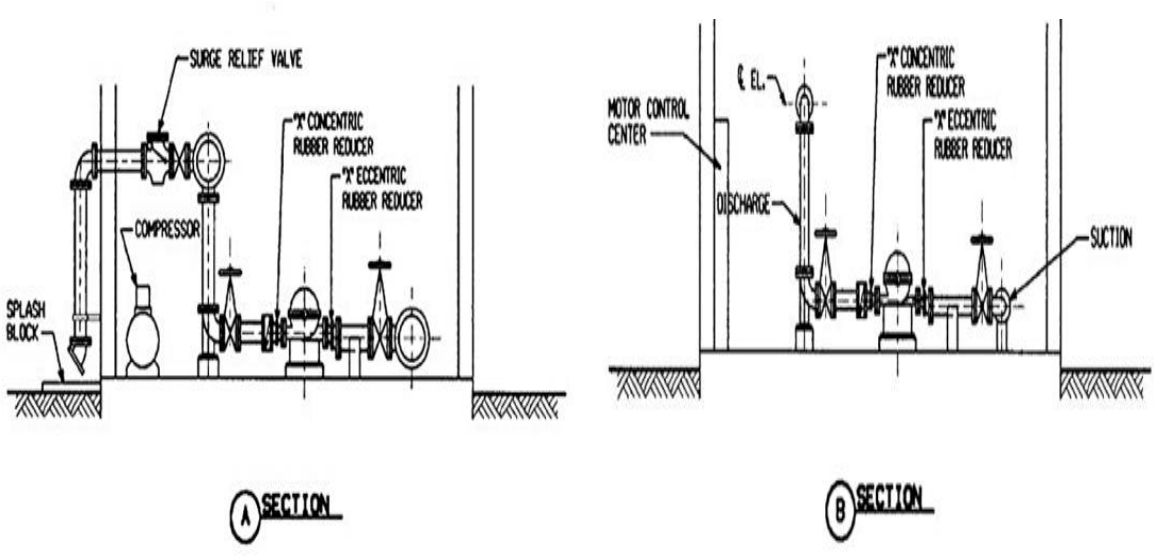


Fig 1.1 sample Pumping Station Typical Layout



9.2 Storage of pumps

If the pump set is to be taken out of service for a long period of time carry out the following procedures: ·

- Drain all the liquid from the pump · Clean and dry all components which have come in contact with liquid · Spray the internal parts of the body especially around the impeller with light penetration oil such as WD40 or, if this is not available, flush body with diesel oil.
- Grease the thread of the suction and discharge ports (openings) and tape off to keep dirt out of the pump body. · Store in a clean dry location away from vibration. · Turn the pump once every 30 days to prevent binding of the bearings and seal face sticking.

Self-Check -9	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. pumps and its control boards should protect from sunshine or rain or dust and is located in appropriate area.

   A. True B. False

2. Pumps location should be free from any insecure item that could inhibit operation, ensure cooling air ventilation screen are clear.

   A. True B. False

3. Which of the following activity is taken out of service for long period of time?

   A. Drain all the liquid from the pump
   B. Grease the thread of the suction ports
   C. Grease the thread of the discharge ports
   D. All

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

Answer Sheet-9

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3.

Information Sheet-10	Identifying teams and individuals' roles and responsibilities within the team

10.1 Introduction to teams

Teams is a group of people with different skills and different tasks, who work together on a common project, service, or goal, with a meshing of functions and mutual support.

10.1.1 Working as a team

Many mechanic units involve projects and investigations that are undertaken by small teams or groups of about 4 or 5.

Reason to work in team are:

- it's good to develop these skills as early as possible.
- Teams are much more effective than individuals for work on complex projects.
- Teamwork develops your interpersonal skills in coping with conflict, in being a chairperson, in developing your interdependence and accountability and in developing your sense of self-esteem. This aids your personal development and your non-work-related relationships.

Team are important because of the following reasons.

- More knowledge and skill are brought to the problem.
- More people are aware of the full breadth of the problem.
- Meetings are more productive and goal-oriented.
- Better decisions are made
- Team problems are identified sooner and more clearly.
- Team members learn from each other.
- The team becomes more cohesive and develops a stronger sense of belonging to the organization.
- Overall morale improves.

- More is accomplished than is possible by equivalent individual efforts.
- Productivity and time savings are achieved by eliminating duplication of efforts.
- Absenteeism and missed deadlines are reduced.
- Team members understand organizational issues better.
- Management work is shared.
- Teams set and achieve tougher goals than individuals.

10.2 Organization structured

A maintenance program must be structured so that it serves the facility. The tasks that an operator or mechanic completes at a small plant are vastly different from those at a larger facility. In some complex organizations, a team of mechanics may serve several facilities. The specific methods employed by one facility may not work at another facility. No matter what size facility, however, organization is required to ensure that all systems are properly managed.

The complexity of a maintenance group depends upon factors such as system size, average age of the system, amount of work that is contracted to outside sources, and the degree of in-house engineering support. However, the basic premise of organizational structure is the same in any plant. Organizational charts, **Standard Operating Procedures**, and maintenance manuals all help the structure of the plant to run smoothly.

An Organizational Chart guides employee through **the hierarchy of the organization**. All workers need to know what they are supposed to do in order to fulfill job requirements, and they need to know who their supervisor is. Therefore, the organizational structure of any plant must have:

- Clearly defined roles and responsibilities
- Clearly defined reporting structure.

Self-Check -10	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. _____ is a group of people with different skills and different tasks, who work together on a common project, service, or goal, with a meshing of functions and mutual support.

   A. Friend B. people C. community D. Team

2. What is the reasons work in team is more effective?

   A. It's good to develop these skills as early as possible.

   B. Teams are much more effective than individuals.

   C. Teamwork develops your interpersonal skills.

   D. All

3. Why use teams?

   A. To make more productive and goal-oriented meetings

   B. To make Better decisions are made

   C. To learn team members from one another.

   D. To flow Information in more effective manner

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

Answer Sheet-10

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1_____

2_____

3_____

Operation Sheet 1	**Techniques for Identifying and clarifying Work requirements from work orders**

Steps to prepare maintenance work order for pump maintenance

Step #1: identify the task

Step #2: create maintenance request

Step #3: prioritize and schedule work order

Step #4: assign and complete the work

Step #5: close and document the work order

Step #6: analyze and/or rework the work order

Operation Sheet 2	**Determining, obtaining and inspecting the size, type and quantity of component**

Steps to Identifying parts and function of pump components

Step #1: identify tools and PPE

Step #2: identify parts and function of pump components

Step #3: clean and return tools and equipment

LAP Test	**Practical Demonstration**

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Giving the necessary equipment's and PPEs you are required to perform the following tasks within 3hours.

Task 1. Prepare work order to maintain a pump

Task 2. Identify parts and function of pump components

Instruction Sheet-2	Learning Guide #26: Remove pumps for maintenance

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

- Confirming the required isolations where appropriate
- Disconnecting pumps
- Removing pumps
- Inspecting pump for abnormalities.

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 –**

- Confirm the required isolations where appropriate in accordance with site requirements
- Disconnect pumps in accordance with the work plan
- Remove pumps in a manner which will assist in replacement in accordance with the work plan
- Inspect pump for abnormalities in accordance with the work plan.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 4”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3, and 4” in each information sheets on pages 62,66,68 and 74
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

6. If you earned a satisfactory evaluation proceed to “Operation sheets 1on pages 75 and do the LAP Test on page 76”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Confirming the required isolations where appropriate

1.1 Introduction to isolations

Before performing repairs or maintenance on any industrial equipment (e.g. Pump), you should always follow standard **"Lock Out/Tag Out"** procedures. This includes not only shutting down the equipment, but also isolating it from any potential power sources (electric, hydraulic, mechanical etc…). In addition, be sure to lock controls and tag the equipment as under maintenance to ensure that it is not accidentally reconnected or activated by a third party. Never activate systems tagged out of service.

Workers performing service or maintenance on machinery and equipment (e.g. when we install or maintain a pump) may be exposed to injuries from the unexpected energization, startup of the machinery or equipment, or release of stored energy in the equipment. To reduce these injure we have to followed some solation procedures.

1.2. solation procedures

1.2.1 Lockout

Lockout devices hold energy isolating devices in a safe or "OFF" position. These devices include switches with a built-in lock, and lockouts for circuit breakers, fuses and all types of valves.

Also, readily available are chains, safety lockout jaws (sometimes called hasps), which accommodate a number of padlocks, and sets of robust safety padlocks.

1.2.2. Tagout

A tag on its own is **not an** effective isolation device. A tag acts only as a means of providing **information** to others at the workplace. A lock should be used as an isolation device, and can be accompanied by a tag.

See the sample form below how to isolate equipment for maintenance or installation

Lockout/Tagout Machine Specific Procedure

Equipment or Process: Baler

Location of Equipment: Box Room

A tag is required on each **Isolation Location** listed below
The Specific **Type of Lock** must be applied at the location listed

Date prepared _____ **Prepared by** XXXX

Type of Energy	Isolation Location	Type of Lockout Device
Electrical	Control Panel	Key
Electrical (Main)	Breaker – rear of machine	Lock
Potential (Stored)	Hydraulic Ram	Block
Kinetic (in-motion)		
Pneumatic (air - gas pressure)	Glue air nozzle	Quick disconnect
Hydraulic	Pressure Bleed switch	Valve Lock
Thermal	Hot Glue	Cool down
Chemical		

Special Hazards	Procedure for Control of Special Hazard
Control Panel energized	If work on control panel – Main breaker must be off.

Special Procedures

Stored Energy Release Procedure

Bleed hydraulic pressure and block ram.

Notes

Isolation Location shall positively identify the exact breaker, valve, switch or other disconnect or blocking device to be locked and tagged to isolate the source of energy from the work area.

Type of Lockout shall specifically name the exact type of locking device needed to ensure the disconnect or blocking device stays in the isolated condition/position. i.e.. Breaker Clip, Valve Handwheel Cover, Blank Flange, etc.

Stored Energy: Following the application of the lockout or tagout devices to the energy isolating devices, all potential or residual energy will be relieved, disconnected, restrained, and otherwise rendered safe.

Blank Form

Lockout/Tagout Machine Specific Procedure

Equipment or Process: _____

Location of Equipment: _____

A tag is required on each **Isolation Location** listed below
The Specific **Type of Lock** must be applied at the location listed

Date prepared _____ **Prepared by** _____

Type of Energy	Isolation Location	Type of Lockout Device
Electrical		
Potential (Stored)		
Kinetic (in-motion)		
Pneumatic (air - gas pressure)		
Hydraulic		
Thermal		
Chemical		

Special Hazards	Procedure for Control of Special Hazard

Special Procedures

Stored Energy Release Procedure

Notes

Isolation Location shall positively identify the exact breaker, valve, switch or other disconnect or blocking device to be locked and tagged to isolate the source of energy from the work area.

Type of Lockout shall specifically name the exact type of locking device needed to ensure the disconnect or blocking device stays in the isolated condition/position. i.e.. Breaker Clip, Valve Handwheel Cover, Blank Flange, etc.

Stored Energy: Following the application of the lockout or tagout devices to the energy isolating devices, all potential or residual energy will be relieved, disconnected, restrained, and otherwise rendered safe.

- When both lockout and tagout are used, it is known as **LOTO**

Fig 7.3 Tag and lock (LOTO)

So, you have added a LOTO on a pump to be maintain.

Self-Check -1	Written test

Directions 1: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. Before performing repairs or maintenance on Pump, you should always follow standard **"**Lock Out/Tag Out**"** procedures.

   A. True B. False

2. When both lockout and tagout are used, it is known as

   A. TALO B. LOTO C. TATA D. LOLO

Directions 2: 3. Fill the following blank format to tagout your pump for maintenance which is available in your shop but it should be maintained for the next. To give the answer for these you should copy the format in your paper in fill it. It contains 4 points.

Blank Form

Lockout/Tagout Machine Specific Procedure

Equipment or Process:_____

Location of Equipment: _____

A tag is required on each **Isolation Location** listed below
The Specific **Type of Lock** must be applied at the location listed

Date prepared _____ **Prepared by** _____

Type of Energy	Isolation Location	Type of Lockout Device
Electrical		
Potential (Stored)		
Kinetic (in-motion)		
Pneumatic (air - gas pressure)		
Hydraulic		
Thermal		
Chemical		

Special Hazards	Procedure for Control of Special Hazard

Special Procedures

Stored Energy Release Procedure

Notes
Isolation Location shall positively identify the exact breaker, valve, switch or other disconnect or blocking device to be locked and tagged to isolate the source of energy from the work area.
Type of Lockout shall specifically name the exact type of locking device needed to ensure the disconnect or blocking device stays in the isolated condition/position. i.e.. Breaker Clip, Valve Handwheel Cover, Blank Flange, etc.
Stored Energy: Following the application of the lockout or tagout devices to the energy isolating devices, all potential or residual energy will be relieved, disconnected, restrained, and otherwise rendered safe.

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

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

Answer Sheet-1

Score = _____
Rating: _____

Name: _____ Date: _____

Answers

1_____

2_____

3_____

Information Sheet-2	disconnecting pumps

2.1 Introduction to disconnecting pump

Disconnecting provides reasonable protection for personnel that may be servicing the **motor** or the equipment (e.g. motor driven pump) driven by the **motor**. Service personnel are able to visually monitor the safety **disconnect** when it is located in accordance within the limits of the in-sight-from rule. Disconnecting pump from its electrical cable should take care to minimize risk.

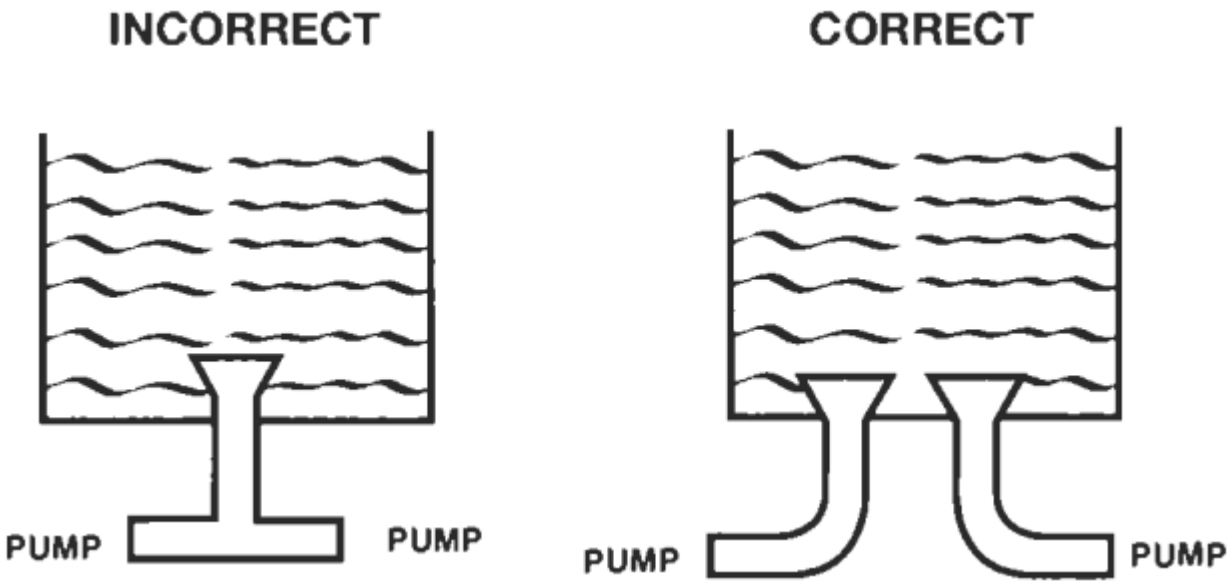
2.2 Connecting pip to pump

We all know that piping is integral to the pump system. Because it is connected to the suction and discharge, the piping affects the health and wellbeing of the pump. Incorrect pipe installation prejudices the pump's useful life.

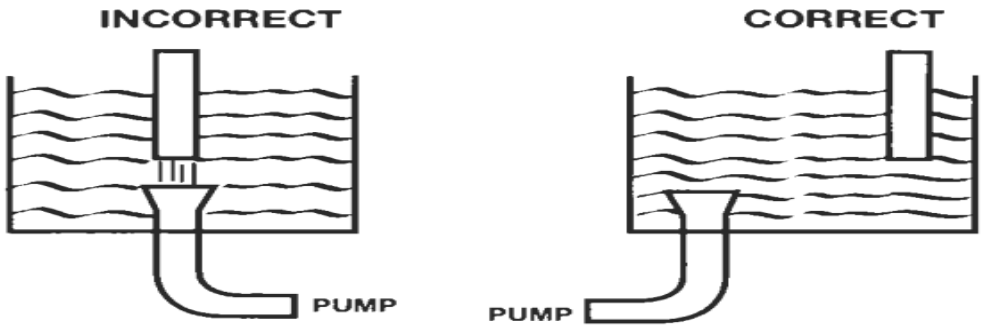
In this information sheet, we present graphic information on inadequate and correct piping arrangements.

- Piping design to drain tanks and sumps

  When draining a tank with two pumps, you should not use a 'T' with two connections. The dominant pump may asphyxiate the other pump. Each pump needs its own supply pipe



- The in-flow pipe should not cause interference with the drain pipe (Figure 17-2).



- Drain pipe design must respect proper submergence (Figure 17-3). The submergence laws appear later in this chapter.

Never connect a pump to piping, unless extra care is taken to measure and align the piping flanges well. Always start piping from pump. Use as few bends as possible and preferably long radius elbows. Do not use flexible connectors on the suction or discharge of a vertical in-line pump, unless the pump is rigidly mounted to a foundation. Ensure piping exerts no strain on pump as this could distort the casing causing breakage or early failure due to pump misalignment. All connecting pipe flanges must be square to the pipework and parallel to the pump flanges. Suction and discharge pipes may be increased or decreased at pump nozzle to suit pump capacity and particular conditions of installation. Use eccentric reducers on suction connection with flat side uppermost.

Pump Piping

We all know that piping is integral to the pump system. Because it is connected to the suction and discharge, the piping affects the health and wellbeing of the pump. Incorrect pipe installation prejudices the pump's useful life.

Self-Check -2	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question has two point.

1. Disconnecting provides reasonable protection for personnel that may be servicing the motor or the equipment (e.g. motor driven pump) driven by the motor.
   A. True B. False
2. Disconnecting pump from its electrical cable should take care to minimize risk.
   A. True B. False
3. Correct pipe installation prejudices the pump's useful life.
   A. True B. False

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

Answer Sheet-3

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____
2. _____
3. _____

Information Sheet-3	**Remove pumps in a manner which will assist in replacement**

3.1 Introduction remove pumps

When we remove pump parts, we have to care and follow company manual how to remove each component step by step. And addition we have also how to remove obstructions to maintain pump.

Removal of obstructions to maintain pump

It often necessary to open the pump to remove obstruction that have lodged in or around the impeller and/or the volute. These procedures are rather basic; however, certain precaution should always be taken

1. Always shut down and lockout / tagout the system
2. Check the suction and discharge valves to ensure they are closed
3. Remove vent or drain plug. This allows the pressure and water to escape from the volute
4. After the flow has stopped, open the pump.
    - Solid case pump is usually equipped with removable inspection plates. After removing the plate, the internal portion of pump is accessible
    - Split case pump does not have inspection plates; however, half the casing can be easily removed for internal inspection.

- Remove the obstruction and inspect the inside of the pump
- Make any necessary repairs, and then put the pump back together
- Prime the pump and put it into operation. Vent any entrapped air from the volute. This is done by slowly opening the vent plug on the volute and allowing the air to escape. caution should be taken when performing this operation because the inside of the volute is under pressure

Self-Check -3	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question has two point.

1. When we remove pump parts, we have to care and follow company manual
   A. True B. False

2. It often necessary to open the pump to remove obstruction that have lodged in or around the impeller and/or the volute
   A. True B. False

3.Correct pipe installation prejudices the pump's useful life.
   A. True B. False

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

Answer Sheet-3

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____
2._____
3._____

Information Sheet-4	Inspecting pump for abnormalities

4.1 Introduction to pump abnormalities

The following factors are the most causes of pump abnormality

- Vibration factors
- Hydraulic factors
- Maintenance factors
- Motor factors

4.1.1 Vibration factors

- Involves for the deterioration and wear of the mechanical components of the pump
- Cause vibration-related problems for pumps are
  - ✓ No attention to coupling fitting, balance, or keys,
  - ✓ Improper selection of seals
  - ✓ Improper lubrication (e.g., too cold, water ingestion and condensation, contamination);
  - ✓ Improper maintenance procedures in shop or bearing selection/fitting wrong.

4.1.2 Hydraulic factors

Major hydraulic phenomena are: cavitation, recirculation, axial thrust radial thrust, and pressure pulsations.

Cavitation

Cavitation is the formation and subsequent collapse of vapor bubbles in any flow that occurs in an ambient pressure equal to or less than the vapor pressure of the liquid being pumped. As the vapor bubbles collapse on metal surfaces, resultant pitting occurs on the surface finish. Deterioration of pump internal can be severe. Cavitation is normally evidenced by a steady crackling noise in and around the pump suction that is accompanied by a substantial increase in vibration and noise level with are duction in total head and output capacity. It should be noted that cavitation in the presence of significant back ground noise may be difficult to distinguish unless acoustical signals are properly conditioned. Cavitation can be minimized by operating with an available net positive suction head.

Pump recirculation

Pump recirculation, the reversal of apportion of the flow back through the impeller, can be potentially more damaging than cavitation. Recirculation at the inlet of the impeller is known as suction recirculation and at the outlet is referred to as discharge recirculation.

1.1.1 Maintenance Factors

Although manifested as a vibration problem, proper alignment is a maintenance issue. Outside of serious unbalance of pump components, there is no single contributor to poor mechanical performance more significant than poor alignment. Incorrect alignment between a pump and its driver can cause

1.extreme heat in couplings,
2.preloadingon the bearings (evident by an elliptical and fattened orbit resembling a partially deflated beach ball), and
3. bearing failures plus thrust transmission through the coupling.

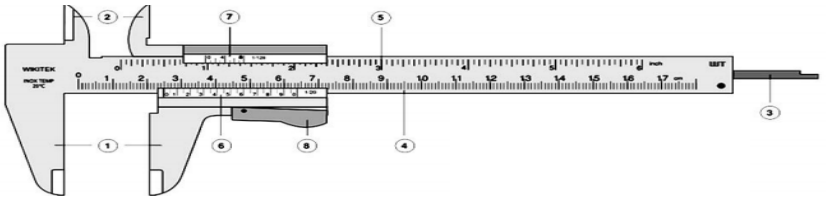
4.1.3 Motor Factors

When evaluating pump performance, it is imperative that the condition of the pump motor be taken into consideration, along with the configuration of the coupling between pump and motor.
Preventive maintenance programs use megohmmeters to routinely measure the insulation's resistance to ground.

4.2 Tools used in pump inspection and maintenance work

4.2.1 Precision measuring instruments: such as Vernier Calipers, Digital Electronic Caliper, Micrometers, Vernier Height Gauges (e.g. Standard Height gauge, Dial Height Gauge, Digital Height Gauge), digital thermometers

- **Vernier Calipers**: is precise tools capable of measuring external and internal dimensions as well as depths. Vernier calipers are precision measuring instruments that give an accuracy of 0.1 mm to 0.01 mm. we use it in pump maintenance to measure shaft diameter, internal diameter of impeller, etc



Key:

1. Outside Jaws- used to take external measures of objects.
2. Inside Jaws- used to take internal measures of objects.
3. Depth probe- used to measure the depth of objects.
4. Main scale(mm)
5. Main scale(inch)
6. Vernier scale(mm)
7. Vernier scale(inch)
8. Retainer- used to block movable part

Fig 4.1 Vernier Calipers with its part

- **Digital Electronic Caliper**
  - Can provide readings to resolution of .0005 in. or 0.01 mm at touch of button
  - No rack, pinion or glass scale
  - Can connect to Statistical Process Control (SPC) equipment for inspection purposes

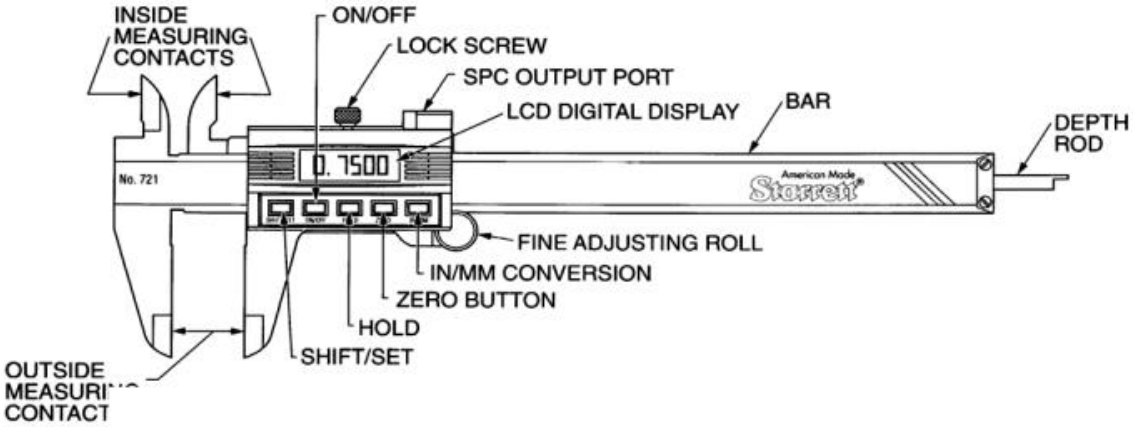
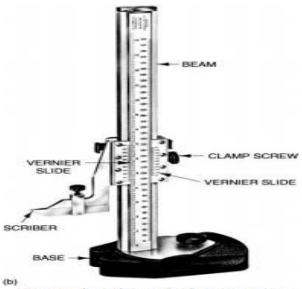


Fig 4.2 Digital Electronic Caliper

- **Vernier Height Gauges**

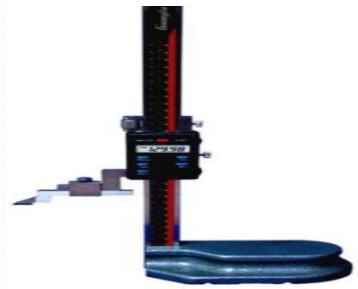
They are designed for use in tool rooms, workshops, inspection departments to measure or mark off vertical heights and locating center distances.

- Variety of sizes: 12-72 in. or 300-1000 mm.
- Accuracy: 0.001 in 0.02 mm
- Offset scriber: Attachment that permits setting heights from face of plate
- Depth gage attachment



Standard Height gauge

Dial Height Gauge



Digital Height Gauge

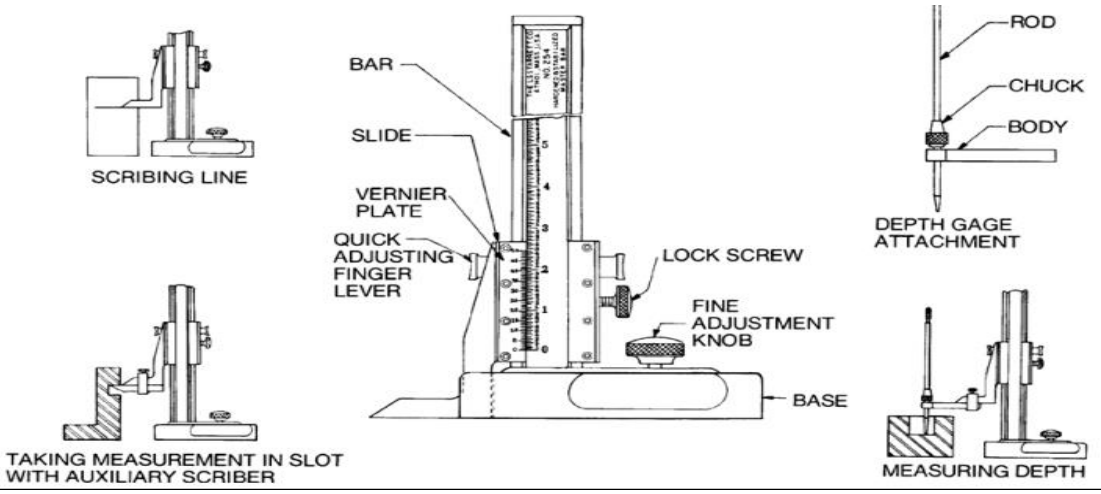


Fig 4.3 Vernier Height Gauges

- **Micrometers**: It is primarily used to measure external dimensions like diameters of shafts, thickness of parts etc. to an accuracy of 0.01 mm.

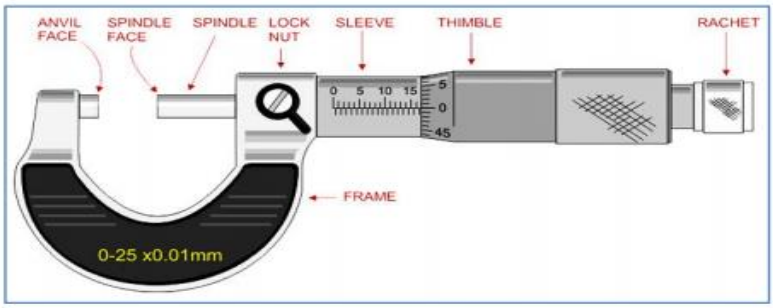


Fig 4.4 Micrometers

- **feeler gauge:** it is used to measure slop

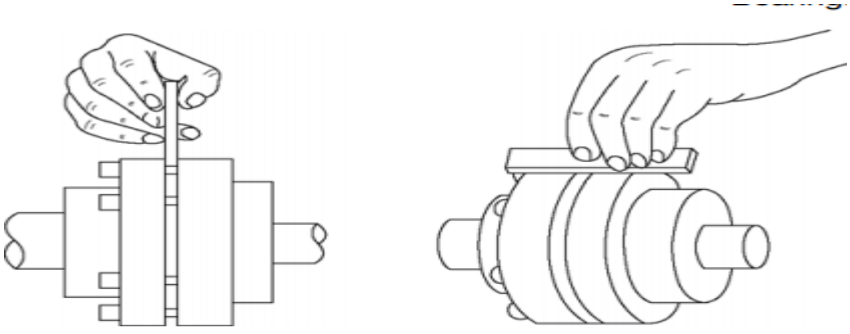


Fig 4.5 Aligning a coupling with feeler gauge and straight edge for simple applications

4.2.2 Electrical Testing instrument/Tools

Some Electrical Testing instrument/Tools which we used in pump maintenance are: multimeter. Meager,

- **multimeter:** used to measure voltage, current, and resistance.

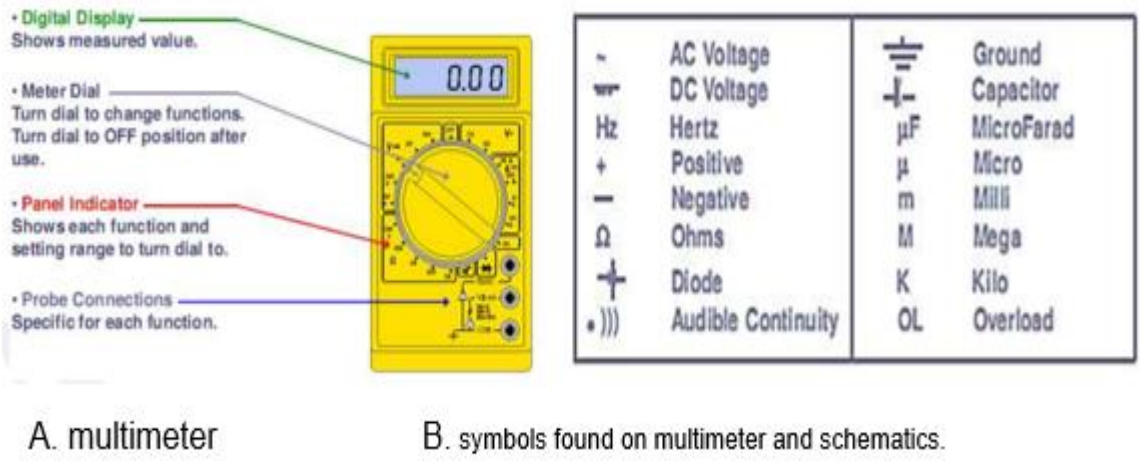


Fig 4.6 digital multimeter

- **Megger ((Megohm insulation tester))**: Used for measuring insulation resistance. We use in pump maintenance Motor winding Insulation resistance test

Fig 4.7 portable megger

- **Surge Test**: Surge testing helps identify a shorted motor conductor turn and as such is a powerful predictor of future motor failure due to turn-to-turn shorting. Failure of conductor insulation is the culprit here and is one of the first signs that a motor is going to electrically fail.

4.2.2 Other testing method for rump

- Visual inspection: for cracking of casing, impeller cavitation
- Bake stator to remove any moisture: to remove **contamination or moisture**

Self-Check -4	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. which of following factors are the most causes of pump abnormality

A. Vibration factors B. Hydraulic factors C. Maintenance factors D. All

2.which of the following is not the cause of vibration-related problems for pumps

A. No attention to coupling fitting and balance B. Improper selection of seals

C. proper lubrication of pump component D. Improper maintenance procedures

3. which of the following instruments used for motor winding Insulation resistance test

A. ammeter B. micrometer C. megger D. voltmeter

4. _____ helps identify a shorted motor conductor turn

A. megger testing B. Surge testing C. insulation testing D. flow testing

Note: **Satisfactory rating - 4points** **Unsatisfactory – below 4 points**

Answer Sheet-4

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____
2._____
3. _____
4 _____

Operation Sheet 1	**Removing pumps,** **Inspecting pump for abnormalities**

Steps to Removing and Inspecting pump components for abnormalities

Step1 Selecting required safety equipment's and tools

Step2 Control Panel

- Check and tighten all terminations
- Inspect and test control panel operation
- Test telemetry/alarms
  the parts of pump and its part are free from damage
- Ensure the cable free from damage

Step3 Check Pump components

- Check parts of pump and its part are free from damage.
- Analyze motor; Surge Test, Megger Test, Winding resistance Tesrt, Visual inspection, Motor winding resistance
- Test the whole electrical connection by using multimeter and megger

Step4 Clean the pump area and return the necessary tools used

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Giving the necessary equipment's and PPEs you are required to perform the following tasks within 3hours.

Task 1. Remove pumps

Task 2. Inspect pump components for abnormalities

Instruction Sheet-3	Learning Guide #27: Maintain pumps

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

- Performing maintenance
- Dismantling Pump for maintenance
- Marking components, noting data and making sketches for identification and/or re-assembly
- obtaining and inspecting new components
- Performing dimensional inspection with precision measuring instrument
- Undertaking modifications /replacement
- Reassembling pump

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 –**

- Perform maintenance in accordance with manufacturer specifications and site procedures
- Dismantle Pump for maintenance in accordance with manufacturer specifications and site procedures
- Mark components, note data and make sketches for identification and/or re-assembly
- obtain and inspect new components for compliance with manufacturer specifications
- Perform dimensional inspection with precision measuring to ensure compliance with specifications devices and recording the results in accordance with job requirements and site procedures
- Undertake modifications/alterations/replacement are in accordance with site requirements
- Reassemble pump by applying appropriate principles and techniques in accordance with manufacturer specifications and site requirements

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 7”. Try to understand what are being discussed.

4. Accomplish the “Self-checks 1,2,3,4,5,6 and 7” in each information sheets on pages 85, 87, 89,92,94,97 and 103.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, on pages 103.and do the LAP Test on page 112”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Performing maintenance

1.1 Maintenance of Pumps

Proper maintenance is vital to achieving top pump efficiency expected life. Additionally, because pumps are a vital part of many HVAC (Heating, Ventilation and Air-Conditioning) and process applications, their efficiency directly affects the efficiency of other system components.

The importance of pumps to the daily operation of buildings and processes necessitates a proactive maintenance program. Most pump maintenance activities center on checking packing and mechanical seals for leakage, performing preventive/predictive maintenance activities on bearings, assuring proper alignment, and validating proper motor condition and function.

1.1.1 Mechanical shaft seals maintenance

- Mechanical shaft seals are maintenance-free, working almost without any leakages.
- If any considerable and increasing seepage occurs, the mechanical shaft seal should be checked immediately.
- If the sliding surfaces are damaged, the entire shaft seal should be replaced.
- Mechanical shaft seals should be treated with the greatest care.

1.1.2 motor maintenance

- Check the motor at regular intervals.
- It is important to keep the motor clean in order to ensure adequate ventilation.
- If the pump is installed in a dusty environment, it must he cleaned and check regularly..

1.1.3 Bearing maintenance

Cleaning bearings and relubrication

A lubricant, either oil or grease, should always be present in the bearings in small quantities. If not, the life of the bearing will be compromised by damage to the bearing surfaces. This damage can be avoided with proper cleaning and relubrication. The intervals for cleaning and re-lubing the bearings are generally long periods.

It's easy to see when a bearing needs oil. Check the oil site level indicator. It's different with grease. It's impossible to determine when a bearing needs more grease. This is because the grease in the bearing does not suddenly lose its lubricating properties. These properties are lost gradually over time. Previous operating experience (history) is a good guide to determine when to add more grease.

The intervals depend on the grease properties, the size and design of the bearing, the operating speed, the temperature, and humidity.

In important process pumps, the grease in a bearing should be changed every 12 to 18 months. This will assure a reliable pump operation and service because time alone causes certain deterioration in the lubricating ability of grease.

The intervals for cleaning and re-lubricating bearings should be more frequent if water or moisture is able to enter into the bearing chamber. Bearings can become contaminated from rain, hose downs, pumps located under dripping equipment, dew, fog and condensation. Entrance points could be through inadequate, worn or failed shaft seals, the breather cap, and the lube oil fill port. Be sure the new grease or oil is not contaminated.

The following table contains some simple 'Do's and Don'ts' for handling and working with bearings. Memorizing and practicing these suggestions will extend the service life of rolling element bearings.

Table 1.1 'Do's and Don'ts' for handling and working with bearings

Do's	**Don'ts'**
Make sure all tools and surroundings are clean	Use only clean, lint-free cloths with no strings to wipe bearings.
Use only clean flushing fluids and solvents.	Don't handle bearings by hand. It's
Use only clean flushing fluids and solvents.	Don't use leaded gasoline to rinse bearings. The chemical additives are harmful to your health.
Don't handle bearings by hand. It's best to use clean cotton gloves.	Don't handle bearings with wet or dirty hands.
Remove all outside dirt from the housing before exposing the bearings.	Don't work in a dirty surrounding.
Make sure the internal bearing chamber is clean before replacing bearings.	Don't scratch or nick any bearing, housing, or shaft contact surface.
Place bearings on clean paper.	Don't expose bearings to rust or dirt.

Keep bearings covered with oil or wax paper when not in use.	Don't spin un-cleaned bearings by hand.
Protect disassembled bearings from dirt and rusting.	Don't spin un-cleaned bearings with a jet of compressed air.
Treat new and used bearings with the same care. Use an **induction heater** for installation.	Don't install bearings with mallets, or hammers and wood blocks.

1.2 Trouble shooting

Before removing the terminal box cover of moto and before removing/dismantling the Pump make sure that the power supply has been switched OFF and that it cannot be accidentally switched ON again.

Table 1.2 Trouble shooting for pump

No.	FAULT	PROBABLE CAUSES	REMEDIAL ACTIONS
1	Pump delivers no or too little liquid.	**a.** Wrong electrical connections phases)	• Check the electrical connections and take remedial action, if necessary.
		b. Wrong direction of rotation.	• Inter change two phases of the power supply.
		c. Air in suction pipe	• Vent the suction pipe or the pump.
		d. Counter pressure too high with the data sheet.	• Set the duty point in accordance. • Check the system for impurities.

		e. Inlet pressure too low.	• Increase the liquid level on the suction side. • Open the isolating valve in the suction pipe. • Make sure that pipe work is complied with the standard recommendations.
		f. Suction pipe or impeller blocked by impurities.	Clean the suction pipe or pump
		g. Pump draws in air due to defective seal.	Check the pipe line seals, pump housing gaskets and shaft seals, and replace if necessary.
		h. Pump draws in air due to liquid level.	Increase the liquid level on the low suction side and keep it as constant as possible.
2.	Motor protective circuit breaker has tripped because the motor is overloaded.	a. Pump blocked by impurities.	Clean the pump.
		. b. Pump running above rated duty point.	Set the duty point in accordance with the data sheet.
		c. Density or viscosity of liquid higher than	If less flow is sufficient, reduce the flow on the discharge side or

		specified when ordering.	fit a more powerful motor.
		d. Motor protective circuit breaker overloads setting incorrect.	Check the setting of the motor protective circuit breaker and replace if necessary.
		e. Motor runs on two phases.	Check the electrical connections; Replace the fuse, if defective
3	Pump makes too much noise. Pump runs unevenly and vibrates.	b. Air in suction pipe or pump.	Vent the suction pipe or the pump.
		c. Counter pressure lower than specified.	Set the duty point in accordance with the data sheet.
		d. Pump draws in air due to low liquid level.	Increase the liquid level on the suction side and keep it as constant as possible.
		e. Impeller out of balance (clogged impeller blades).	Clean and check the impeller
		f. Inner parts worn.	Replace the defective parts.
		g. Pump stressed by pipe work (thus causing starting noise).	Mount the pump so that it is not stressed. Support the pipes.

		h. Defective bearings.	Replace the bearings.
		i. Defective motor fan.	Replace the fan.
		j. Foreign bodies in pump.	Clean the pump.
4	Leaking pump connections or mechanical shaft seal.	a. Pump stressed by pipe work (thus causing leaks in pump housing or at connections).	Mount the pump so that it is not stressed. Support the pipes.
		b. Pump housing gaskets and gaskets at connections defective.	Replace pump housing gaskets or gaskets at connections.
		c. Mechanical shaft seal dirty or stuck together.	Check and clean the mechanical shaft seal
		d. Mechanical shaft seal defective.	Replace the mechanical shaft seal.
		e. Shaft surface defective.	Replace the shaft.
5	Too high	a. Air in suction pipe or pump.	Vent the suction pipe or the pump and replenish.

	temperature in pump or motor.	b. Inlet pressure too low.	Increase the liquid level on the suction side. Open the isolating valve in the suction pipe. Make sure that pipe work is complied with the standard recommendations.
		c. Bearings lubricated with too little, too much or unsuitable lubricant.	Replenish, reduce or replace the lubricant.
		d. Axial pressure too high.	Check the relief holes of the impeller and the lock rings on the suction side.
		e. Motor protective circuit breaker defective or setting incorrect.	Check the setting of the motor protective circuit breaker and replace, if necessary.
		f. Motor overloaded.	Reduce the flow rate.

Pumps Checklist

A pump maintenance checklist is a tool used by pump technicians or engineers when conducting pump inspections. Pump inspection checklists guide inspectors during pump inspections to help ensure that the pumps are in good working condition.

prepare the following before performing pump maintenance checks:

1. **Inspection Tools**

   Make sure to have the right pump maintenance checklists, manuals, and inspection tools for the corresponding pumps that will be checked.

2. **Personal Protective Equipment (PPE)**

Wear the right PPE to mitigate workplace risks like slips & falls and prevent loose or unrecommended clothing from getting snagged by machinery.

3. **Go Signal to Proceed**

   Do not perform pump maintenance checks without receiving the go signal to proceed. Maintenance checks may require machines and valves to be shut off or proper clearance before inspectors can enter premises (tool box talk, lockout tagout, permit to work). Also always immediately report any missing machine guards or pump shields should you observe these during inspections.

Table1.1 pump checklist sample

Description	Comments	Maintenance Frequency			
		Daily	Weekly	Monthly	Annually
Pump use/sequencing	Turn off/sequence unnecessary pumps	X			
Overall visual inspection	Complete overall visual inspection to be sure all equipment is operating and safety systems are in place	X			
Check lubrication	Assure that all bearings are lubricated per the manufacture's recommendation			X	
Check packing	Check packing for wear and repack as necessary. Consider replacing packing with mechanical seals.			X	
Motor/pump alignment	Aligning the pump/motor coupling allows for efficient torque transfer to the pump			X	
Check mountings	Check and secure all pump mountings			X	
Check bearings	Inspect bearings and drive belts for wear. Adjust, repair, or replace as necessary.				X
Motor condition	Checking the condition of the motor through temperature or vibration analysis assures long life				X

Self-Check -1	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. Proper maintenance is vital to achieving top pump efficiency expected life.

   A. True B. False

2. Which of the following is a pump maintenance activity

   A. checking packing B. mechanical seals for leakage

   C. checking the alignment shafts D All

3. What is the possible cause; If the centrifugal pump delivers no or too little liquid.

   A. Wrong electrical connections phases B. Wrong direction of rotation

   C. Air in suction pipe D. All

Note: **Satisfactory rating - 3points** **Unsatisfactory – below 3 points**

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

Answer Sheet-2

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____
2. _____
3. _____

Information Sheet-2	Dismantling Pump for maintenance

2.1 Introduction to dismantling/ Disassembly of pump

Dismantling of components of pump should perform based on the manufacturer specification and recommendation which found on the manual of each specific pump type. So, you should follow the manual and interpret their drawing and codes perfectly and then demonstrate it. Dismantling/ Disassembly is the reverse of assembling process.

- **Most common tools used for dismantling pump are**
  - Wrenches
  - Screwdriver
  - Lifting Sling
  - Rubber Mallet
  - Induction Bearing Heater
  - Bearing Puller
  - Brass Drift Punch
  - Snap-Ring Pliers
  - Torque Wrench with Sockets
  - Allen Wrenches
  - Cleaning Agents
  - Feeler Gauges
  - Hydraulic Press
  - Leveling Blocks

- **Dismantling bearings**

  One of the most important precautions required during assembly and dissaembly of rolling bearings is cleanliness. Both the bearing and the housing must be carefully inspected for any traces of dirt or other inclusions. If they have to be dismantled for more than several hours, or for a shorter period of time in a dusty environment, they should be protected by wax paper or lintless rags.

  A rolling bearing usually has an interference fit with either the shaft or the housing. When the interference fit is on the shaft, the bearing should never be forced in place by applying pressure to its outer race. Similarly, when the interference fit is in the housing, only the outer race should be subjected to force during mounting. During assembly, care should be taken to ensure that surfaces of the bearing races should move parallel to the mating surfaces of the shaft or the housing. Any cocking of a bearing while it is being driven into position may damage both the races and the rolling elements.

Self-Check -2	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. Dismantling of components of pump should perform based on the manufacturer specification and recommendation

   A. True B. False

2. Which of the following tools mostly used for dismantling pump

   A. Wrenches B. Bearing Puller

   C. Rubber Mallet D All

3. One of the most important precautions required during assembly and dissaembly of rolling bearings is cleanliness

   A. True B. False

Note: **Satisfactory rating - 3points** **Unsatisfactory – below 3 points**

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

Answer Sheet-2

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____
2. _____
3. _____

Information Sheet-3	Marking components, noting data and making sketches for identification and/or re-assembly

3.1 Introduction to marking, noting data and making sketches

The various components of a complete job maintenance pump include:

- job steps;
- tool list;
- bill of materials (BOM) and parts list;
- diagrams, photographs, illustrations;

Job steps

The recommendation is to begin by writing down the actual job steps. The procedure should be written as a **numbered list** with each number representing one of the finite steps of the job. The steps should be recorded in the order they are to occur. If the planner happens to be a former technician who has performed the task before, then this portion of the process should be pretty straightforward.

Tool list

Once the job steps have been written down in order and checked for errors or omissions, the next step is to analyze the job with an eye to constructing the tool list.

The tools referred to here are in addition to those that we would normally expect to find in a workshop—they are specific tools required to do the job.

These items used include cranes, alignment and measurement devices (micro meter, vernier caliper, dial indicators, digital height gauges, digital thermometers) specialty tools, power tools (e.g. grinders, jigs and fixtures) and a large variety of other things not needed for maintenance of pump

Bill of materials and parts list

Parts should be listed by both part number and description, and no mentainance plan should progress to the ready stage until every part is on hand and has been verified to be the correct part. This specificity is not only important with regards to parts. Materials such as, epoxy, oils, grease, nuts, bolts, washers, rubber hose, O-rings and hundreds of other non-job-specific materials must be listed on the job plan.

When the job is scheduled, these materials must be verified as being on-hand and available for use. In addition to being a complete record of all parts and materials, your BoM and parts list should also indicate any special disposal instructions for removed or replaced parts.

Self-Check -3	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. which one of the following is a components of a complete job maintenance pump?
   A. job steps B. tool list C. BOM D. All
2. Job steps written as a **numbered list** with each number representing one of the finite steps of the job

   A. True B. False
3. In BoM Parts listed by both part number and description
   A. True B. False

Note: **Satisfactory rating - 3points** **Unsatisfactory – below 3 points**

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

Answer Sheet-2

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____
2. _____
3. _____

Information Sheet-4	**obtaining and inspecting new components for compliance with manufacturer specifications**

4.1 Introduction to inspection of maintenance of pump

A maintenance inspection is the process of evaluation the condition of equipment or machines. The purpose of a maintenance inspection is to determine what tools, materials, and labor are needed to keep them in good working condition.

In a maintenance and installation program, inspections include tasks that check the condition of equipment and determine what tools, materials, and labor are required to service them.

Maintenance inspections can identify minor issues before they turn into costly repairs. Inspections ensure machines are working correctly and helps prevent equipment downtime.

- **Maintenance inspection programs may include the following best practices:**
  - Condition-monitoring routes cover all needed inspections
  - Simple inspection tools including a stroboscope, bright flashlight, infrared thermometer, vibration pen, mirrors and industrial stethoscope are readily available
  - Guards or other protective gear can be removed in order to check belts, couplings, and chains in action
  - Oil containers and other clear gauges and base bolts are clean and facilitate accurate inspections
  - Maintenance staff is educated and trained in basic inspection processes
- Types of maintenance inspections are:

  Safety inspections: These inspections check the operation of back-up or protective devices that cannot be readily checked unless a primary system fails. Failure instances must be simulated to test these components of equipment or machinery.

  Building interior inspections: Check walls, ceilings, and floors for damage, leaks, or other deterioration. Be sure to remove hazards and ensure proper operation of doors and locks. Restroom areas should be inspected for problems, and alarms should be tested.

  Building exterior inspections: Check paint, walls, windows, and doors for damage regularly as well as any foliage that may damage the walls or foundation. Inspect the roof, drains, and gutters. Inspect sidewalks, driveways, and railings for hazards and damage. The overall campus should be inspected for debris as well as outdoor hazards like fallen branches.

Plumbing inspection: It include checking for leaks, noises, and damage. Water boosters, water chillers, condenser fans, and circulation pumps must be lubricated, and water boilers and heaters should be fire-tested. Sewage and sump pumps should be inspected regularly and replaced as needed.

Self-Check -4	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. A maintenance inspection is the process of evaluation the condition of equipment or machines.
   A. True B. False
2. Maintenance inspections can identify minor issues before they turn into costly repairs.

   A. True B. False
3. Inspections ensure machines are working correctly and helps prevent equipment downtime.
   A. True B. False

Note: **Satisfactory rating - 3points** **Unsatisfactory – below 3 points**

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

Answer Sheet-4

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____
2. _____
3. _____

Information Sheet-5	**Performing dimensional inspection with precision measuring devices and recording the results**

5.1 Introduction to dimensional inspection

Handy technology can help pump maintenance technicians and engineers conduct effective pump inspections by proactively capturing issues and taking immediate action to mitigate problems. iAuditor, the world' s most powerful mobile inspection app, can help accomplish the following:

- **Proactive maintenance inspections**
  A. Schedule routine inspections to maintain the good working order of pumps
  B. Be aware if a scheduled pump inspection is missed
  C. Assign immediate action for urgent issues found during pump maintenance checks
- Mobile
  - ✓ Take photos of issues using your mobile device during inspections
  - ✓ Make notes to better describe the nature of the issue
  - ✓ Conduct mobile inspections even in spots that do not have reception
- Automated recordkeeping
  - ✓ Automatically organized cloud-based recordkeeping of pump inspections
  - ✓ Inspection reports can be submitted via weblink or PDF document
- Analytics
  - ✓ Use customized scoring to measure inspection results and watch out for recurring issues
  - ✓ Geotagged inspections help identify sites of inspection results
- Streamline pump maintenance
  - ✓ Assign pump inspections, gather reports, collect photo evidence, analyze trends, and integrate iAuditor with other platforms and systems used in your organization to streamline routine pump maintenance checks

Self-Check -5	**Written test**

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. A maintenance inspection is the process of evaluation the condition of equipment or machines.

A. True B. False

2. What to do a technical in proactive maintenance inspections of pump
   A. Schedule routine inspections to maintain the good working order of pumps
   B. Be aware if a scheduled pump inspection is missed
   C. Assign immediate action for urgent issues found during pump maintenance checks
   D. All

Note: **Satisfactory rating - 3points** **Unsatisfactory – below 3 points**

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

Answer Sheet-2

Name: _____Date: _____

Answers

1. _____
2._____

Score = _____

Rating: _____

Information Sheet-6	**Undertaking modifications/alterations/replacement in accordance with site requirements**

6.1 Introduction to modification pump component

We may modify different pump component during maintenance operation to fit its performance such as impeller, shaft, casings, bearings, and so on. But the modification of such component should meet manufacturers specification.

Operations to alter components of pump parts are:

- Heat treatment of metals such as Annealing, Normalizing,

Annealing: consists of heating the metal to a suitable temperature, holding at that temperature for a certain time (called soaking), and slowly cooling. It is performed on a metal for any of the following reasons: 1) to reduce hardness and brittleness, (2) to alter microstructure so that desirable mechanical properties can be obtained, (3) to soften metals for improved machinability or formability, (4) to recrystallize cold-worked (strain-hardened) metals, and (5) to relieve residual stresses induced by prior processes. We may use these processes in pump maintenance to alter some components of pump such as impeller, shaft to get the desired outcome.

- **Surface hardening:** Surface hardening refers to any of several thermochemical treatments applied to steels in which the composition of the part surface is altered by addition of carbon, nitrogen, other elements.
- **Welding:** is a material joining process which produces coalescence of materials by heating them to suitable temperatures with or without the application of pressure or by the application of pressure alone, and with or without the use of filler material. We use welding for general repair work of pump in these cases.

Fig 6.1 Worker is welding the pump's impeller for repair

- **Chemical Cleaning:** uses various types of chemicals to effect contaminant removal from the surface.
- **Mechanical cleaning and surface treatments:** Mechanical cleaning involves the physical removal of soils, scales, or films from the work surface of the work part by means of abrasives or similar mechanical action. The processes used for mechanical cleaning often serve other functions in addition to cleaning, such as deburring and improving surface finish. We use these processes during rusting and wearing of components of our pump.

Self-Check -6	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. Which of the following operations we used to alter(modified) components of pump?
   A. Annealing: B. Surface hardening
   C. welding C. All
2. Mechanical cleaning involves the physical removal of soils, scales, or films from the work surface of the work part by means of abrasives or similar mechanical action.
   A. True B. False
3. _____is a material joining process which produces coalescence of materials by heating them to suitable temperatures
   A. Welding B. Annealing
   C. normalizing C. Quenching

Note: **Satisfactory rating - 3points** **Unsatisfactory – below 3 points**

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

Answer Sheet-2

Name: _____Date: _____

Score = _____
Rating: _____

Answers

1. _____
2._____
3._____

Information Sheet-7	**Reassembling pump**

7.1 Introduction to pump reassembly

A machine is an assembly of various links or parts. It is necessary to understand the relation between the various parts of the unit for the purpose of design and production.

The key process of pump assembly is the final dimensional check. If components do not have the correct fit or clearance it will be very apparent. Selective assembly of components is frowned upon unless the components are always supplied as a sub-assembly. Spare parts cannot be selectively assembled on site. Assemblies may have fits, clearances and alignment measured and recorded before testing or dispatch. This record is sometimes called a "History Sheet"

The development of digitally controlled pumping systems, along with computer aided drafting and manufacturing, has made economical the factory production of these systems. Factory-assembled pumping systems have had the same natural development as other equipment that is prefabricated.

Obviously, the size of the pumps, motors, and piping determine whether a pumping system is to be factory assembled or field erected. The largest factory-assembled pumps and motors now appear to be around 300 hp. Piping up to 36 in in diameter has been factory assembled although there have been exceptions to this.

Reassembly comes after disassembling replacement of the part which modified or replace with the new one.

After you completely clean and inspect the pump and the parts of it, reassemble the pump as prescribed by the manufacturer's manual. In all assembly operations, be careful to remove burrs and use a good pressure lubricant on the mating surfaces during all pressing operations. A good pressure lubricant aids in pressing and prevents scoring and galling. Use flat steel washers. They go next to the aluminum to prevent goring by the spring steel lock washers.

The following sample for how to reassembly for pump SUPERFLO®HIGH PERFORMANCE PUMP

Steps to Reassembly for super flow high performance pump as manual states blow

1. When installing the replacement seal into the seal plate, use soapy water to wet the rubber boot before pressing it into the seal plate.
2. Remount the seal plate to the motor.
3. Before installing the rotating portion of the seal on the motor shaft, wet the motor shaft with soapy water and slide the seal onto the motor shaft. Ensure that the carbon face contacts the ceramic face of the stationary seat. Press the seal into the seal plate with your thumbs and wipe off the ceramic with a clean cloth.
4. Grease the motor shaft thread and screw impeller onto the motor shaft.
5. Screw in the impeller lock screw (counterclockwise to tighten).
6. Remount the diffuser onto the seal plate. Make sure the plastic pins and holding screw inserts are aligned.
7. Grease the diffuser quad ring and seal plate O-ring prior to reassembly.
8. Grease the bolt threads, assemble the motor subassembly to the strainer pot-pump body by using the two through bolts for proper alignment. Do not tighten the through bolts until all 4 bolts are in place and finger tightened
9. Fill the pump with water.
10. Reinstall the pump lid and plastic clamp; see the next section, '**Restart Instructions'.**

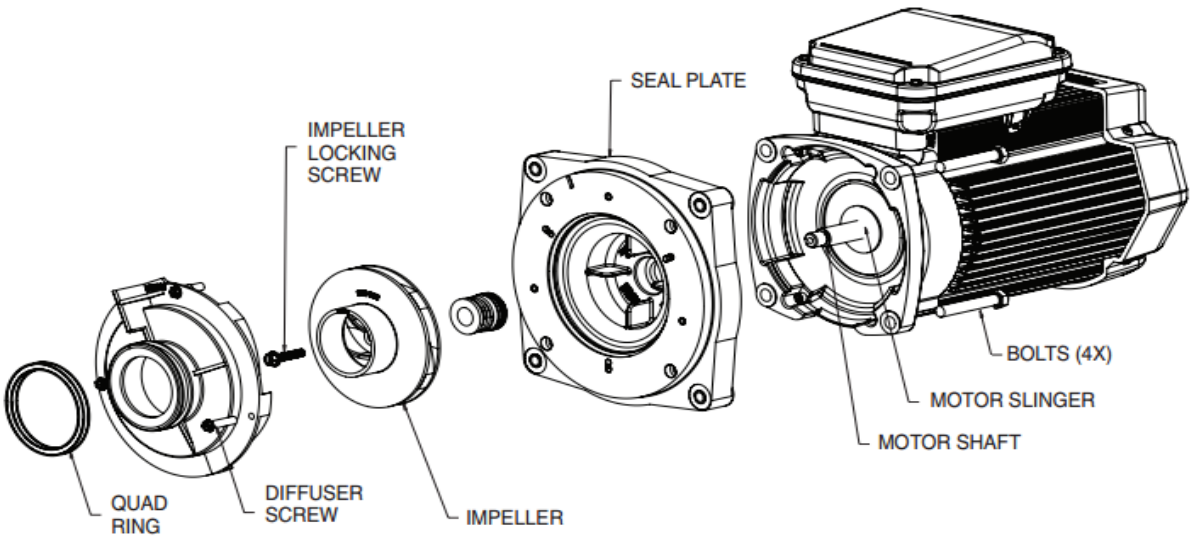
11. Reprime the system

Restart Instructions:

If pump is installed below the water level of the pool, close return and suction lines prior to opening hair and lint pot on pump. Make sure to re-open valves prior to operating. The pump strainer pot must be filled with water before the pump is initially started.

Follow these steps to prime the pump:

1. Remove the pump lid plastic clamp. Remove the pump lid.
2. Fill the pump strainer pot with water.
3. Reassemble the pump cover and plastic clamp onto the strainer pot. The pump is no ready to prime.
4. Open the air release valve on the filter, and stand clear of the filter.
5. Turn on the switch or time clock.
6. When water comes out of the air release valve, close the valve. The system should now be free of air and recirculating water to and from the pool.
7. For 2-speed pumps:
   - Pump should run on high-speed for priming.
   - The pump should not run longer than 8 minutes before priming is achieved.



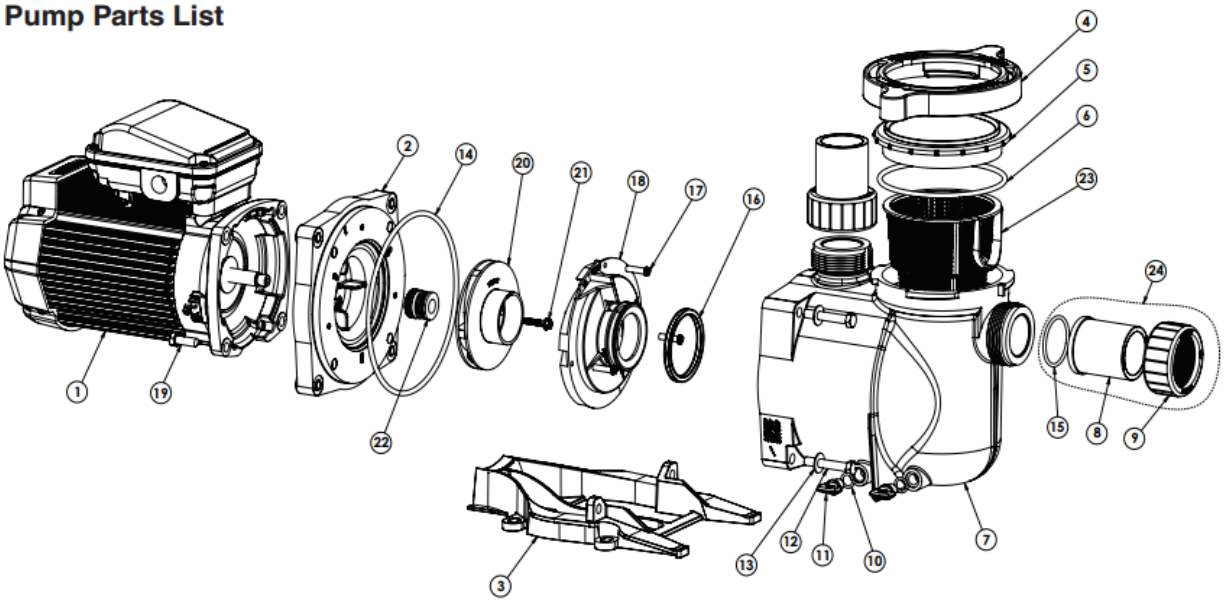
Motor Assembly

SUPERFLO® High Performance Pump Installation and User's Guide

Fig 7.1 motor sub assembly

REPLACEMENT PARTS

Pump Parts List



Item No.	Part No.	Description
***SINGLE* SPEED MOTORS**		
1	355018S	½, ¾ HP
1	355020S	1 HP
1	355022S	1½ HP
1	355024S	2 HP
1	355026S	2½ HP
***DUAL* SPEED MOTORS**		
1	350088S	¾ HP 115 VOLTAGE
1	355003S	1 HP
1	356630S	1½ HP
1	071320S	2 HP
***ENERGY EFFICIENT* MOTORS**		
1	355008S	½, ¾, 1 HP
1	355010S	1½ HP
1	355012S	2 HP
1	355014S	2½ HP
TEFC MOTORS		
1	354821S	1 HP
1	354823S	1½ HP
1	354815S	2 HP
2	356012	SEAL PLATE
3	350094	BASE
4	350090	CLAMP, RAMP & CAM
5	350091	LID
6	357255	O-RING, LID #2-357
7	350089	VOLUTE

Item No.	Part No.	Description
8	350093	ADAPTER, 2 req.
9	350092	NUT, 2 req.
10	192115	O-RING DRAIN PLUG, 2 req.
11	071131	DRAIN PLUG, 2 req.
12	355621	SCREW ¾-16 X 2¼ HEX HD, 4 req.
13	072184	WASHER 3/8 in. S/S, 4 req.
14	355619	O-RING SEAL BRACKET
15	6020018	O-RING ADAPTER #2-226, 2 req.
16	355030	SEAL DIFFUSER
17	355334	SCREW #8-32 HEX WASHER HD, 3 req.
18	355617	DIFFUSER - ½-1HP ODP
18	355618	DIFFUSER - 1½-2HP ODP and 1-1½HP TEFC
18	350170	DIFFUSER - 2½HP ODP and 2HP TEFC
19	U30-74SS	HEX HEAD SCREW 3/8 - 16, 4 req.
20	355043	IMPELLER ½-¾HP ODP
20	355067	IMPELLER 1HP ODP and 1HP 2-SPD
20	355074	IMPELLER 1½HP ODP, 1½HP 2-SPD and 1HP TEFC
20	355086	IMPELLER 2HP ODP, 2HP 2-SPD and 1½HP TEFC
20	355093	IMPELLER 2½HP ODP and 2HP TEFC
21	355389	SCREW, IMPELLER LOCKING
22	354545S	SEAL SET
23	355667	BASKET, LARGE
24	350157	KIT UNION SUPERFLO (Items No. 8, 9, 15)
-	357923Z	FAN GUARD KIT, TEFC/SUPER-DUTY

Self-Check -7	Written test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. A pump is an assembly of various links or parts.

   A. True B. False

2. The key process of pump assembly is the final dimensional check
   A. True B. False

3. Reassembly comes after disassembling replacement of the part which modified or replace with the new one.

   A. True B. False

Note: **Satisfactory rating - 3points** **Unsatisfactory – below 3 points**

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

Answer Sheet-2

Score = _____

Name: _____Date: _____

Rating: _____

Answers

1. _____

2._____

Operation Sheet 1	**Dismantling Pump for maintenance** **Reassembling pump**

Steps/ Procedures to disassembly and assembly Engine Drive Pump:

1.Select required safety equipment's and PPE

2.Select tools and equipment's to disassemble

3.. Remove the four outer pump housing bolts.

4.. Remove the outer pump housing cover.

5.Remove the volute from the pump back plate.

6.Remove the outer pump housing to pump back plate gasket.

This will be a good time to check the gasket for cracks, tears

and overall condition. Replace if necessary.

7.Loosen the impeller by hitting on one of the blades in a counter clockwise position with a rubber mallet.

8.Turn the impeller by hand in a counter clockwise position until free from the crankshaft of the engine.

9. Pull the impeller away from the pump back plate and make sure that any shim(s) that might be positioned on the crankshaft or the impeller be saved and counted.

10. Pull the engine away from the frame.

11. For engine service work, or seal replacement, the pump back plate will need to be removed. Loosen and remove the four bolts with Allen or socket wrench.

12. Pull the pump back plate away from the engine.

13. The engine in now separated from the pump components for service.

14. To remove the stationary seal from the back plate it will be necessary to turn the pump back plate face down on the workbench. Take a 3/4 inch socket and position it into the cavity behind the seal.

15. Hit the backside of the socket until the seal drops to the workbench below.

16. This is what the seal will look like when in new condition. The sealing face will not have gouges, cracks, chips or burnt edges. Replace if any of the previous conditions apply.

17. To remove the rotating seal from the impeller it might become necessary to apply some liquid soapy water to loosen it from the impeller. After the soapy water loosens the seal in the impeller, take a small screw driver and pry gently upward making sure not to scratch the surface.

18. The impeller must be inspected for no cracks, chips, and blades that are missing or broken off. Replace with new if these conditions apply.

19. Check the condition of the volute seal for cracks, worn spots, and overall condition. Replace with new if necessary.

20. Check the condition of the volute. If cracked chipped or bent, it must be replaced.

21. When reinstalling the back plate to the engine make sure the weep whole faces downward. Weep hole must be free from debris.

22. When replacing with a new seal, silicone compound is not needed. However, if original seal is removed and replaced back into pump back plate, then a small amount of silicone sealant will help seal it. Place a thin bead of sealant around the metal part of the seal.

23. Place the seal over the pump back plate for alignment.

24. Using a 1”-inch socket, place the socket over the seal for installation.

25. After setting the seal in the pump back plate, set the socket over the top.

26. Tap the seal into position, looking at the position of the seal after each blow of the hammer to make sure it is installing evenly.

27. After the seal has been installed place the pump back plate over the crankshaft and loosely install one of the bolts to hold it in position.

28. A small amount of thread locker compound should be used on the tip of the bolts. This thread locker should be a service replaceable type.

29. After placing the bolts into the back plate, tighten the bolts snugly. Proper torque clearance should be 2.2 to 3.7 ft. lbs

30. If the pump came installed with shim(s) they must be replaced with same number that came off. If none were installed originally, then do no put a new shim on unless gap between impeller and volute is wider than the tolerance allows.

31. The side of the rotating seal that has the colored warning mark on it must be facing towards the impeller and not facing towards the other seal face.

32. To help installation of the seal and rubber grommet that holds it in the impeller, it might become necessary to place a little liquid dish washing soap and water around the seal to help slip it into the cavity of the impeller.

33. Using two thumbs press the seal into the cavity making sure that the rubber grommet does not bind. The seal should be even and level.

34. Turn the impeller on the crankshaft in a clockwise position until hand tight.

35. Tighten the impeller with a rubber mallet by hitting on one of blades in a clockwise position until tight.

36. The casting marks on the pump back plate indicate where the volute must be placed. Make sure that the volute is placed correctly inside these marks.

37. After installing the rubber gasket on the face of the volute, place the volute on the pump back plate. Tip the unit back slightly to hold it in position.

38. Make sure there is enough clearance between the volute and impeller; use a feeler gauge to check the gap. While holding the volute tightly against the pump back plate, insert different size feeler gauge blades until the correct reading is obtained. The recommended clearance is 0.024 to 0.039 thousand of an inch.

39. Place the outer cover over the pump back plate. It might make it easier if the pump is tipped back and the volute is in position. Do not forget the outer pump housing to back plate gasket.

40. Tighten the four bolts comfortably. The recommended tightening torque is 9 to 11 ft.lbs

41. If necessary, to remove the intake nozzle, remove the three bolts that hold it in position.

42. Watch the position of the gasket and nozzle when removing from the pump housing. Also note the correct position of the gasket tab which should be facing upward.

43. This picture shows the correct placement of the gasket to the intake nozzle housing.

44. Tighten the three outer bolts, making sure not to over tighten. The gasket will be distorted and squeezed when over tightening these bolts. The recommend tightening torque is 3.3 to 4.8 ft. lbs.

45. Pull the engine over by the start pull cord, making sure nothing is binding in the pump.

46. After adding priming water and fuel, start the unit and check with test vacuum plate to make sure there are no vacuum leaks. The recommended vacuum reading at sea level should be 25 lbs of vacuum.

No	Part Name	Disassembly	Operation Performed	Tool Used

47. To assemble go reverse of disassemble procedures
48. Clean and return the necessary tools that you used

LAP Test	**Practical Demonstration**

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Giving the necessary equipment's and PPEs you are required to perform the following tasks within 3 hours.

Task 1. Disassemble and assemble Engine Drive Centrifugal Pump

Instruction Sheet-4	Learning Guide #28: Replace/install pumps

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

- Preparing Site for pump replacement
- Replacing pump
- levelling, aligning, coupling and connecting Pump
- Torqueing all fastenings
- Test running, monitoring and adjusting machinery/plant and pump as required

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

- Prepare site for pump replacement in accordance with the work plan
- Replace pump in accordance with the work plan and manufacturer specifications

- level, align, couple and connect Pump in accordance with the work plan
- Torqueing all fastenings in accordance with manufacturer specifications and site requirements
- Test run, monitor and adjust machinery/plant and pump as required in accordance with manufacturer specifications and site requirements

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 5”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3,4, and 5” in each information sheets on pages 121,125,138,142 and 146.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, 2 and 3 on pages 147 and 148.and do the LAP Test on page155”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Preparing Site for pump replacement

1.1 Introduction site preparation of pump (for surface pump)

The space allocated for the pump must be sufficient to permit installation, care, disassembly and maintenance. Transport routes and lifting facilities must be available. Sufficient space must be available around the installed pump for the access of personnel. Operators may need to make frequent running adjustments. Maintenance personnel will require space to remove components and assemblies. Some pump designs require withdrawal space at the non-drive end. The motor may need space for the withdrawal of the rotor. The building or plot must have drainage facilities for leakage and priming and for liquids used for flushing sealing devices as well as water if used for quench. The risks of flooding the pump unit, in addition to the electrical and control systems, which can be very costly and time consuming to dry out, must also be taken into account. The pump should be sited as low as possible in relation to the liquid level in the suction system and in a place permitting the shortest possible suction pipe with the minimum number of bends.

- **Ventilation**

The ventilation of the pump site is very important. The electric motor of the pump must receive the necessary cooling. If hazardous liquids, harmful to the environment or highly flammable, are to be pumped, special ventilation requirements must be observed. It should be noted that the heat

generated by the pump's electric motor can be considerable. The electrical and control systems for the pump must also be protected against damage.

- **Foundations**

With the exception of pumps directly incorporated into the piping, as well as some submersible pumps and site pumps fitted with **skids or trailers**, a pump requires a solid foundation. This may be of concrete or a steel structure. Standard pump baseplates are designed to be grouted to a continuous concrete foundation block. If the pump is to be installed on a steel structure, the pump manufacturer should be informed of the size and position of the steelwork. Baseplate modifications may be necessary**.**

Pump Installation factors:

- Bases, sole plates, foundations
- Shaft alignment
- Piping
- Environmental effects on application
- Even the right pump for the job will fail if not installed properly.

Foundation of centrifugal pumps without base frame

The foundation/installation must be carried out in accordance with the following instructions. Non-compliance may result in functional faults which will damage the pump components.

- This is recommended that install the pump on a plane and rigid concrete foundation which is heavy enough to provide permanent support for the entire pump.
- The foundation must be capable of absorbing any vibration, normal strain or shock. As a rule of thumb, the weight of the concrete foundation should be 1.5 times the
- weight of the pump.
- The concrete foundation must have an absolutely level and even surface.
- Place the pump on the foundation, and fasten it.
- The foundation length and width should always be 200 mm larger than the length and width of the pump.

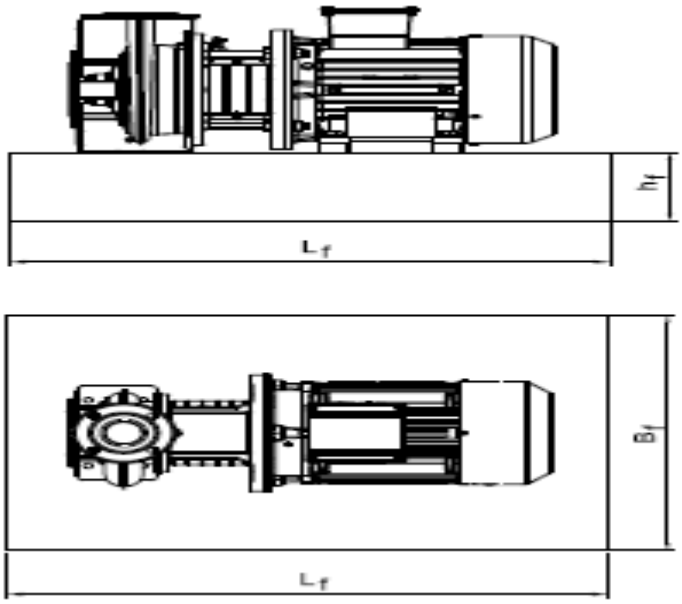


Fig 1.1 Foundation

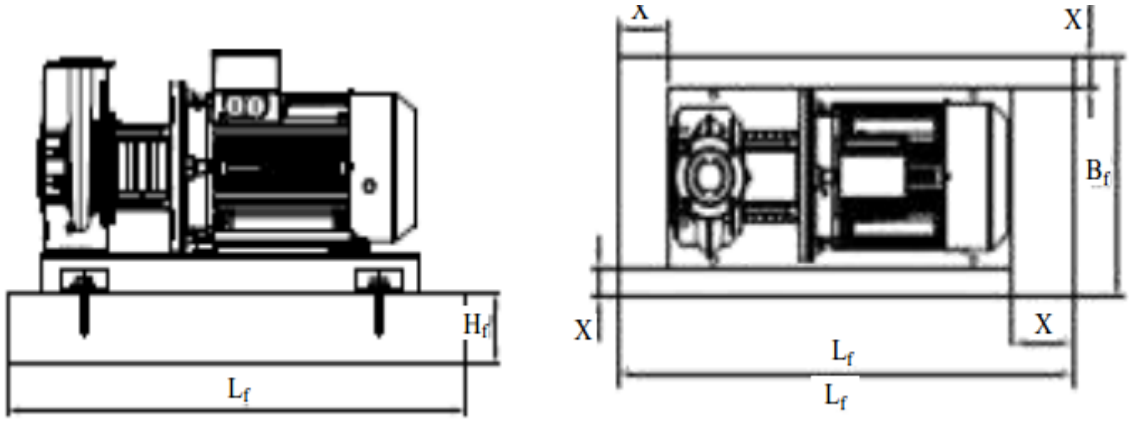
- The mass of the foundation must be at least 1.5 times the total mass of the pump. The minimum height of the foundation (hf) can be calculated

$$h_f = \frac{m_{pump} \times 1.5}{L_f \times B_f \times \delta_{concrete}}$$

- The density (δ) of concrete is usually taken as 2,200 kg/m. In installations where noise-less operation is particularly important, a foundation with a mass up to 5 times that of the pump is recommended.

Foundation of centrifugal pumps with base frame

- It is recommended that install the pump on a plane and rigid concrete foundation which is heavy enough to provide permanent support for the entire pump
- The foundation must be capable of absorbing any vibration, normal strain or shock. As a rule
- The foundation should be 100 mm larger than the base frame on all four sides. See figure below:



Foundation, X=min. 100mm

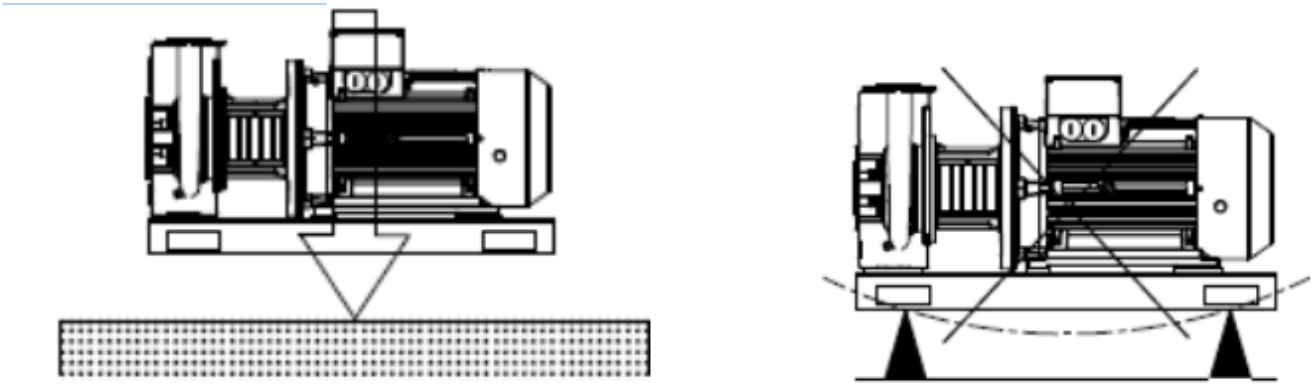
Fig 1.2 Foundation of centrifugal pumps with base frame

The minimum height of the foundation (h) can then be calculated.

$$h_f = \frac{m_{pump} \times 1.5}{L_f \times B_f \times \delta_{concrete}}$$

The density (δ) of concrete is usually taken as 2,200 kg/m

- Place the pump on the foundation, and fasten it. The base frame must be supported under its entire area.



Correct foundation

Incorrect foundation

Fig 5.3 foundation look

1.2 Sit Preparation for Handpump (Afridev Handpump) Installation/replacement)

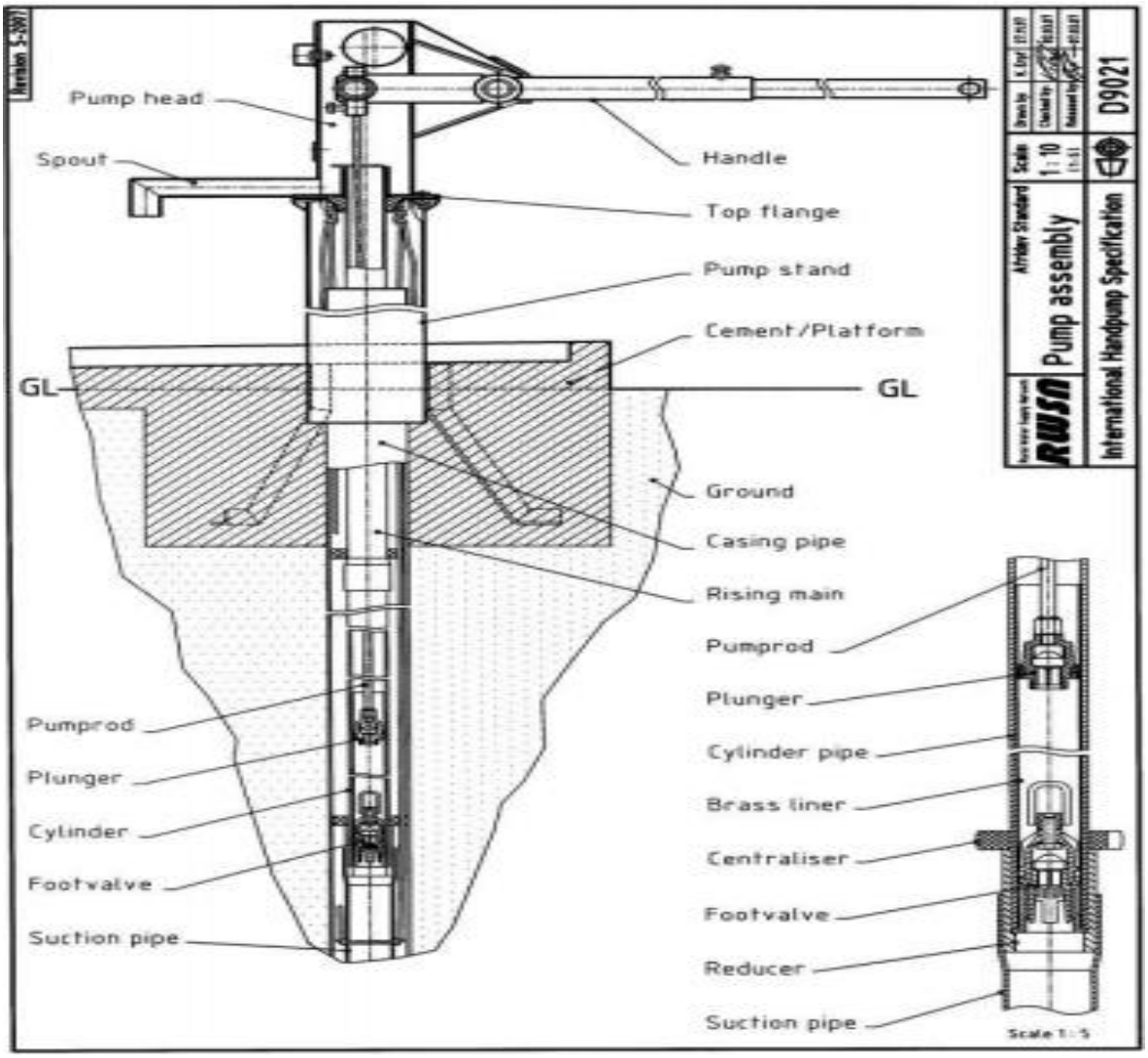


Fig 5.4 Afridev Handpump drawing

1.2.1 Decision on correct Cylinder Setting Depth

1.2.1.1 Static Water Level (SWL)

The SWL can vary due to seasonal conditions (dry or wet seasons) and therefore should be checked and recorded over a period of several years. Such records would be important for the decision at what depth the cylinder should be placed.

Checking the depth of the SWL in a dug-well can be done through the manhole or a special hole provided in the well cover, the same procedure is more difficult if an Afridev is installed in a borehole. The pump head cover, the handle and the pump rods need to be dismantled, before checking of the SWL can start.

1.2.1.2 Dynamic Water Level (DWL)

Apart from seasonal fluctuations, there are also fluctuations in the well itself because of pumping water from the well. In order to check the drop in the water level (draw down) and to find the

DWL, test pumping on a new borehole should be done by the drilling crew.

1.2.1.3 Other important factors

Any pump intake in a bore hole must be set above the well screen in fully screened well or above any rock fissures providing water in an unlined well.

A pump intake above the well screen or rock fissures is minimizing the turbulent flow of water and therefore reduces the pumping of fines and silts

- Pumping water with a too high content of fines or silt is wearing the surface of the pump cylinder and the plunger seals in an unacceptable rate.
- If a pump cylinder is placed too close to the bottom of a borehole, silt and sand could build-up and trap the pump in the hole.

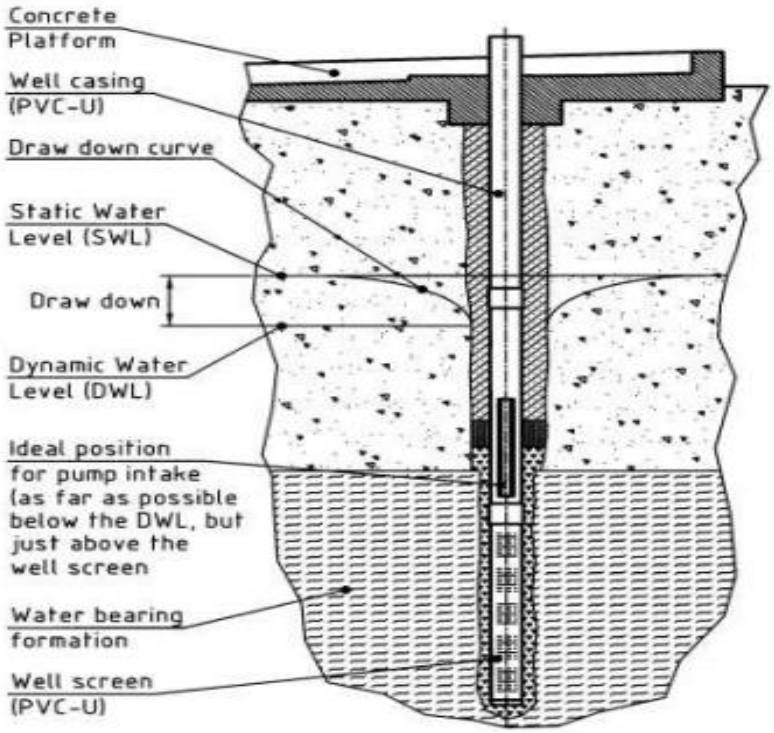


Fig 5.5 Afridev Handpump which show SWL, DWL

1.2.1.4 Material and Tools required for Installation of Afridev Handpump

Tools and Equipment

a) Measuring tape -marking exact length and square cutting line,
b) Pencil / permanent marker _ marking prior to cutting,
c) Hacksaw _ easy cutting of PVC-U pipes,
d) Pocket knife _ deburring of inside edges (inside chamfering),

e) Rasp or coarse file _chamfering the inside and outside edges,

f) Sand paper 60 – 80 grit _roughening of jointing surfaces,

g) Brush, flat 50 x 4 mm _for outside application of solvent cement,

h) Brush, flat 25 x 3 mm _for inside application of solvent cement,

i) White absorbent paper cleaning paper (or toilet paper),

j) Small bowl (Bakelite or tin) -for easy application of solvent cement,

Material

a) Cleaning fluid Carbon tetra chloride base,

b) Solvent cement Tetrahydrofuran base

Self-Check -1	**Written Test**

Direction I: Choose the best answer for the following questions. Use the answer sheet provided in the next page: Each question contains two point

1. The space allocated for the pump must be sufficient to permit installation, care, disassembly and maintenance.

   B. True B. False

2. The ventilation of the pump site not important.

   A. True B. False

3. Which of the following is a pump installation factors?

   A. Bases, sole plates, foundations

   B. Shaft alignment and Piping

   C. Environmental effects on application

   D. All

4. The foundation of surface pump must be capable of absorbing any vibration, normal strain or shock.

   A. True B. False

Note: **Satisfactory rating - 4points** **Unsatisfactory - below 4. points**

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

Answer Sheet-1

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____
2._____
3._____

Information Sheet-2	**Replacing pump**

2.1. Pump installation/replacement

The installation of pumps can be carried out by the pump manufacturer, the driver manufacturer or the contractor building the installation. Large pumps are usually installed as early as possible while access at site is at its best. Small pumps can usually be fitted in at any time. The pump should be ordered so that its delivery occurs at the correct time in the overall site programme.

2.1.1 Vertical pump installation

- Pumps fitted with motors up to and including 4 kW require a 0.3 m clearance above the motor.
- Pumps fitted with motors of 5.5 kW and up require at least a 1-meter clearance above the motor to allow the use of lifting equipment.

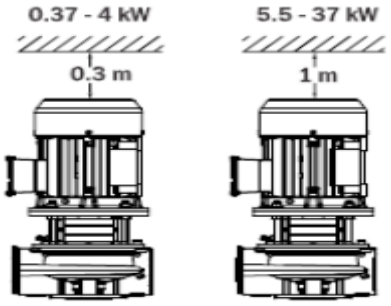


Fig 2.1 Clearance above the motor

2.1.2 Horizontal Installation

- Pumps fitted with motors up to and including 4 kW require a 0.3 m clearance behind the motor.

- Pumps fitted with motors of 5.5 kW and up require a 0.3 m clearance behind the motor and at least a 1-meter clearance above the motor to allow the use of lifting equipment.

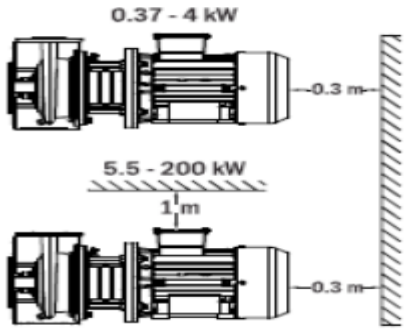


Fig2.2 Clearance behind the motor

Pipe work

- When installing the pipes, make sure that the pump housing is not stressed by the pipework.
- The suction and discharge pipes must be of an adequate size, taking the pump inlet pressure into account.
- Install the pipes so that air locks are avoided, especially on the suction side of the pump.

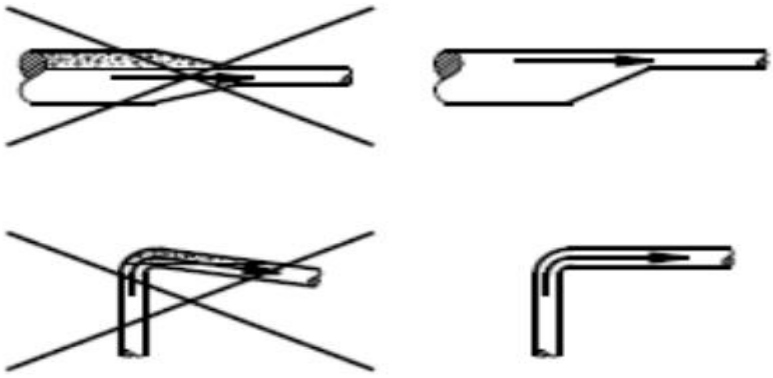
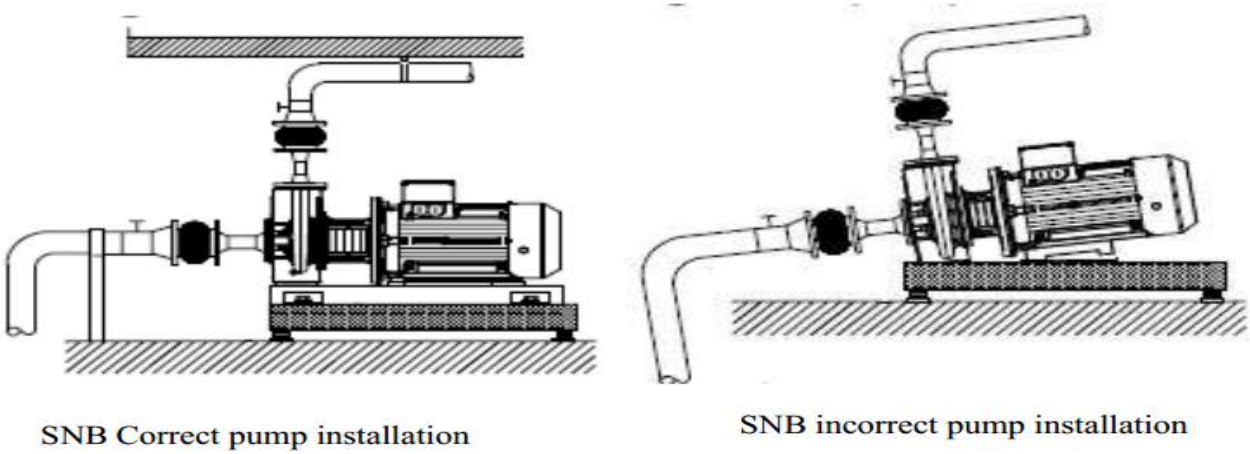


Figure2.3: Pipelines

- Fit isolating valves on both sides of the pump to avoid having to drain the system if the pump needs to be leaned or repaired.
- Make sure the pipes are adequately supported as close to the pump as possible, both on the suction and the discharge side.
- The counter flanges should lie true against the pump flanges without being stressed as stress would cause damage to the pump.



SNB Correct pump installation

SNB incorrect pump installation

Fig 2.4

2.1.3 submersible pump installation /replacement

Before an installation is carried out, the site or bore hole data must be known. Also, a pump and motor starter should be kept.

- We must check the riser pipes to make sure that the tread, coupling is in perfect condition (flanges)
- Check the motor lubrication liquid to make sure it is full and no leagues
- Ensure we use the right size and quantity of cables
- Check ground and each conductor resistance.
- Check the resistance between each conductor cable (short ckt)
- Ensure that all cables joined are completely water tight.
- Before lowering ensure that pump and pipes are well fastened
- Clamp the pump /pipes properly
- Lower the pipes slowly and avoid vibration and tilting
- Check electrical cables while lowering to make sure they are free
- Use cable clips at interval to fasten cables to the pipes.
- Complete lowering with a proper well head and outlet for cables
- Make sure plumping and electrical connection from the well head is proper to motor stator or water supply source
- Check the motor rotation
- Check the riser pipes to make sure the tread, coupling is in perfect condition (flanges)

Self-Check -2	Written Test

Direction II: Choose the best answer for the following questions. Use the answer sheet provided in the next page: Each question contains two point.

1. The installation of pumps can be carried out by the pump manufacturer, the driver manufacturer or the contractor building the installation
   A. True B. False
2. The suction and discharge pipes must be of an adequate size, taking the pump inlet pressure into account
   A. True B. False
3. Before installing /replacing a submersible pump that what we check
   A. Check ground and each conductor resistance.
   B. Check the motor rotation
   C. Check ground and each conductor resistance.
   D. All

Note: **Satisfactory rating - 3points** **Unsatisfactory – 3 below points**

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

Answer Sheet-2

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3.

Information Sheet-3	**Levelling, aligning, coupling and connecting Pump**

3.1 Pump and Motor Alignment

Pump shaft and driver shaft alignment is very important for long useful equipment life, and to extend the running time between repairs. Besides, good alignment reduces the progressive degradation of the pump.

If the pump shaft and impeller assembly were perfectly balanced and aligned, it would rotate in a perfect orbit around the shaft centerline. This condition is practically impossible. There is always some imbalance in the shaft and impeller assembly due to its casting and machining process, and perfect alignment doesn't exist. Because of this, the shaft spins eccentrically around the centerline. We could call this movement 'eccentric rotation'. The implications of a pump exhibiting rotary assembly imbalance (eccentric rotation) include:

- Excessive running noise.
- Vibration and excessive loads on the bearings causing premature failure.
- Rapid wear of the coupling and eventual premature failure.
- Premature packing or mechanical seal failure.
- Wear and rubbing between close tolerance rotary and stationery
- elements in the pump leading to their failure.
- Premature driver bearing failure.

- Increased energy consumption.

There are two basic types of misalignment, angular and parallel. Within each of these basic types of misalignment there are combinations of both. These are the most common combinations:

- Vertical/angular misalignment (Figure 3.1)
- Vertical/parallel misalignment (Figure 3.2)
- Horizontal/angular misalignment (Figure 3.3)
- Horizontal /parallel misalignment (Figure 3.4)
- Combined angular and parallel misalignment

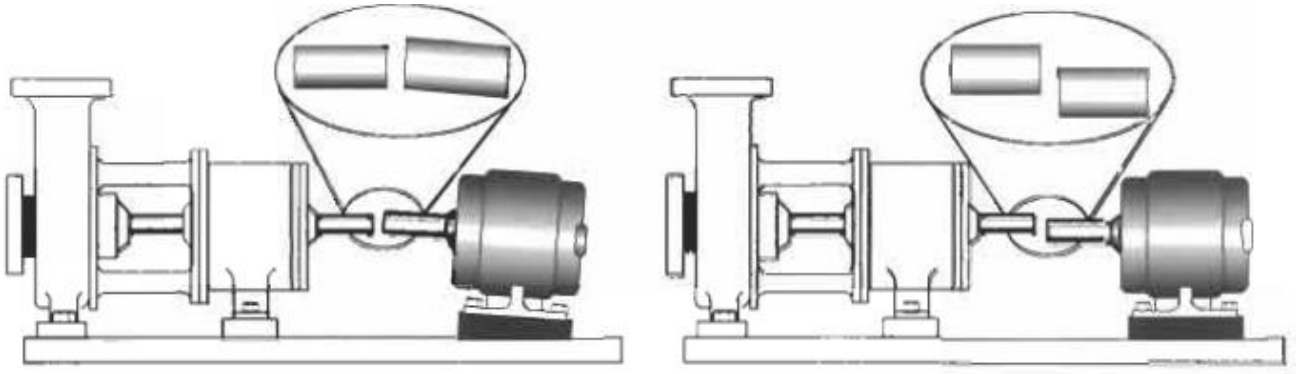


Fig 3.1 Side view of vertical/angular and vertical/parallel misalignment

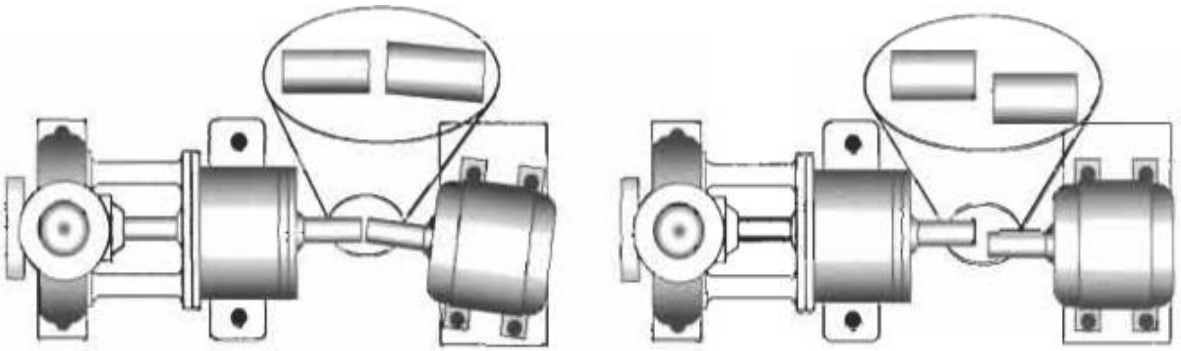


Fig 3.2 Top view of horizontal/angular and horizontal/parallel misalignment

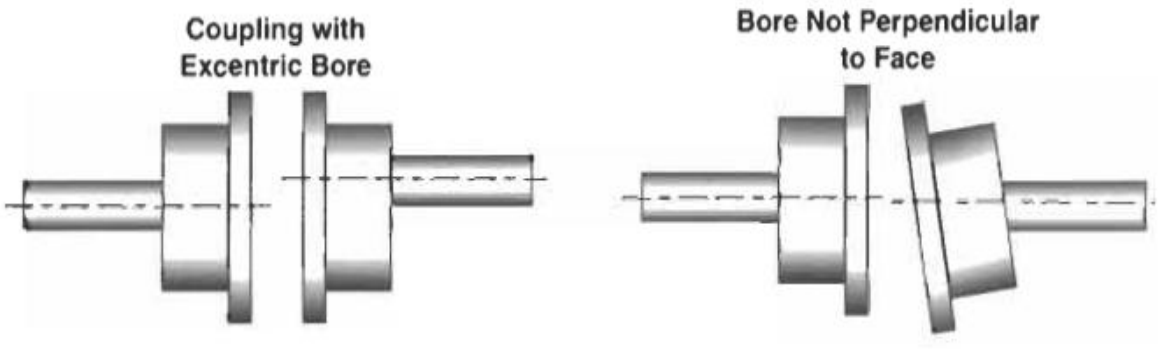


Fig 3.3 Misalignment can be transmitted through the couplings and coupling faces.

Alignment techniques

There are a variety of shaft alignment procedures. The configuration and size of the equipment determines the best alignment method. Generally, the driver or motor should be aligned to the pump. The motor shaft centerline should be shorter and brought up to the pump shaft centerline with shims or spacers. The pump is generally fixed and attached to the suction and discharge piping, so it is almost impossible to move. The volute casing aids in supporting the piping, so it should be fixed to a solid foundation without shims, jack bolts, or supports. Verifying the alignment of running equipment is critical to maintain the correct operation and reduce downtime. Most established alignment procedures call for the use of precision dial indicators to correct misalignment. Gaining popularity in industry is laser alignment technology. We'll cover this shortly. Among the most popular methods of alignment are:

- Reverse Dial Indicator alignment.
- Rim and Face alignment.
- Straight Edge alignment.
- Laser Alignment.

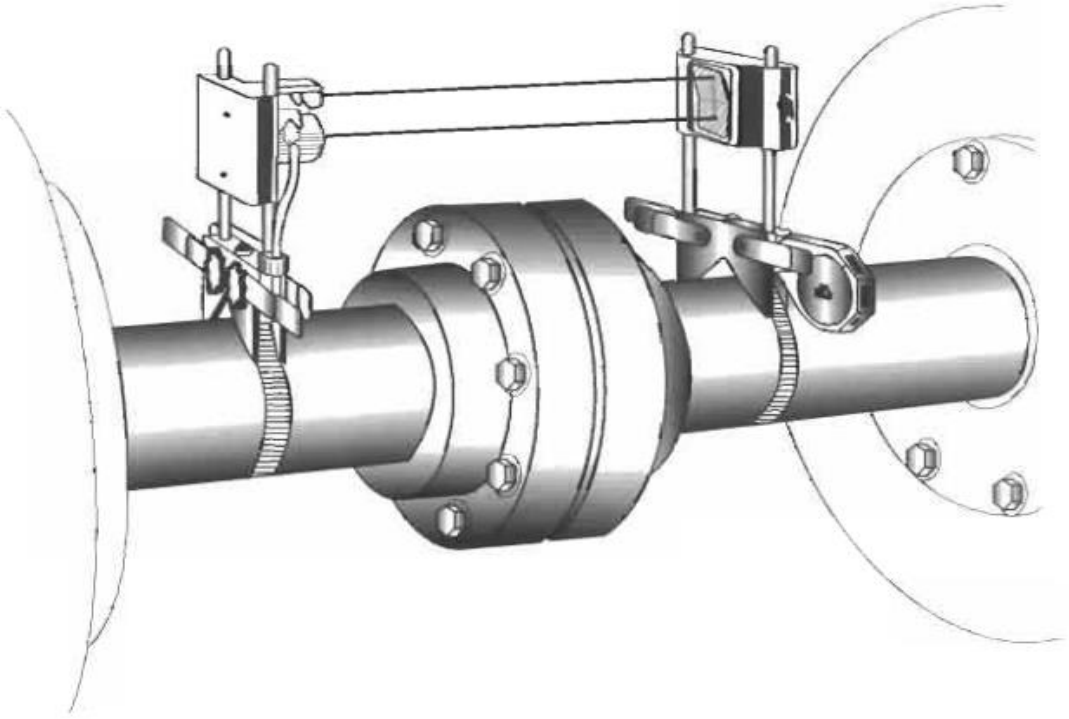


Fig 3.4 Laser Alignment

General observations on the alignment process between shafts

1. The alignment procedure should be repeated at various intervals to identify installation errors and compensate for equipment operation. This is the way to assure long equipment life. It is recommended to go through the alignment procedure and make corrections in the following stages:
    - At Pump Installation: Be sure the motor shaft centerline is below the pump shaft centerline so that it can be shimmed upward. Make sure the motor mount bolt holes have sufficient play to allow for some lateral adjustment. Many pumps and motor assemblies are shipped from the factory on a common channel iron base plate. The manufacturer alleges that they are already aligned at the factory. You need to verify and correct this alignment in all cases.
    - After connecting the piping and accessories: Before starting the pump, repeat the procedure after all associated connections have been made. If there is a marked difference, the problem may be pipe strain distorting the pump casing through the suction and discharge nozzles. This situation should be resolved with the installation contractor or pipe fitters. Not correcting this situation is sure to bring future maintenance problems from misalignment.

- Hot alignment: Allow the equipment to run for three or four hours and come up to operating temperature, then shut-off the pump and repeat the alignment procedure with the equipment hot.
- Running alignment: Mer the pump has been running for a week or ten days, perform an alignment check to verify that the equipment is not suffering pipe strain or binding from thermal growth.

2. The base and cement foundation should be examined to verify a correct installation. The pump and motor assembly should rest on a common base.
    - The base should be sufficiently strong to withstand the machinery weight and minimize vibrations. Five times the mass is the rule. If the pump, motor, and base plate weighs 1,000 lbs, the foundation should weigh at least 5,000 lbs.
    - The base should be level and flat.
    - The base should be the proper size. This varies according to its size and weight. It should have enough free adjacent space to perform maintenance, alignment and proper cooling.
3. The grout should be the correct type for the climate and application temperature, speeds, and chemical nature.
    - Its function is to absorb the vibrations generated by the motor and pump.
    - It should contain aggregate or epoxy.
    - It should be applied strictly according to manufacturer's recommendations.
4. Bases
    - The driver or motor shaft should be level and parallel with the base.
    - Shims should be free of dirt and corrosion. They should be replaced from time to time because they can become deformed with time and weight.
    - Bases should be inspected for corrosion and corrected if necessary.
5. The Motor
    - During the alignment procedure, follow your plant lockout/tagout procedure to prevent accidents.
    - Motor sleeve bearings require limiting the axial play.
    - Study the coupling manufacturer's instructions to assure the proper spacing between the faces. The spacing is relative to the motor size.
6. Dial indicators

- During the alignment it is important to note the direction of the indicator movement. Beginning at 0.000 inches, a movement in a clockwise direction is a positive reading. A counterclockwise movement indicates a negative reading; see Figure 10-10.
- Rotating the shaft and dial 360°, the left lateral reading plus the right lateral reading should equal the sum of the superior and inferior readings.
- The indicator readings at the end of the rotation should be the same as the readings at the beginning of the rotation.

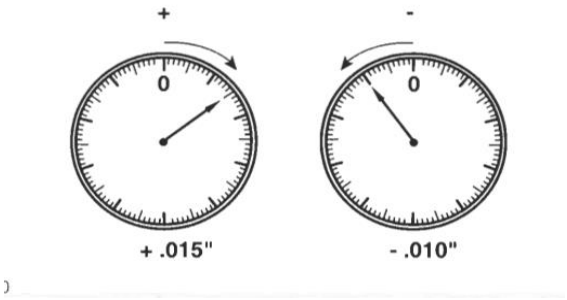


Fig 3.5

7. Shims
    - Spacer shims should be made of 304 stainless steel, except with chlorine and hydrochloric acid service. In these services, use Mylar shims to resist corrosion.
    - It is best to use the thickest shim possible instead of numerous thin shims, which can suffer from compression. Never stack more than 3 shims under an equipment foot.
    - Measure shims to verify their thickness and tolerance, especially thin shims (those less than 0.005 inch).
    - Avoid the use of shims with the thickness stamped on the shim face.
    - Use shims large enough to completely cover the equipment footprint. Avoid rust, scratches, gouges, creases, indentations, hammer blows and dirt.
8. Alleviate any possible pipe strain, a force imposed by the piping that can distort the pump casing.
    - Pipe strain is normally caused by misalignment between the piping and the pump nozzles, improper pipe supports, or thermal expansion in the system.
    - Don’t connect the piping to the pump until the cement base and grouting is fully cured, and all foundation bolts are tightened.

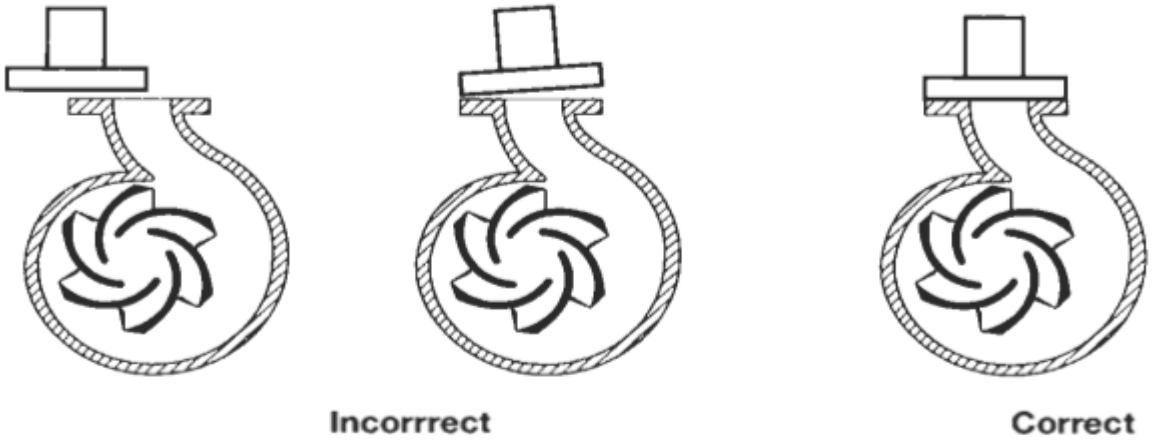


Fig 3.6

- Bring the pipe to the pump and adjust it to the pump. Don't adjust the pump to the piping (Figure above).
- To verify pipe strain, place dial indicators on the shaft and watch for horizontal and vertical movement. Unite the flanges one at a time continually observing the indicator readings. In general, the indicator readings should not exceed 0.002 inches (Figure below)

9. Correct Soft Foot. Soft foot exists when one of the four machinery feet is not level with the base. When the base bolts are tightened with soft foot, the effect can distort and misalign the pump casing.
   - To check for soft foot, place a dial indicator onto the machinery foot, and loosening the base bolt. If the indicator moves more than 0.002 inches, the foot is soft and it should be corrected. Go through the same procedure on the remaining feet one at a time.

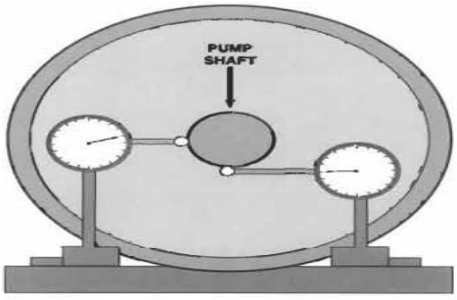


Fig 3.7

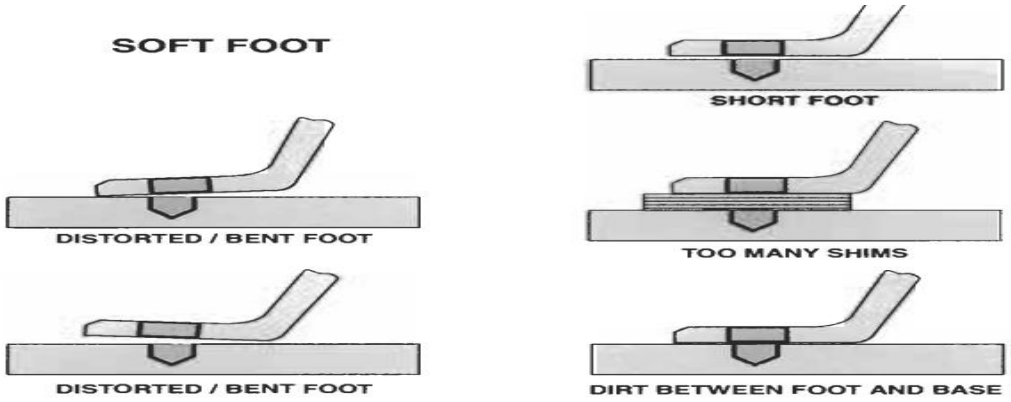


Fig 3.8

- To correct soft foot, place shims under the foot in the thickness corresponding to the movement of the dial indicator.
- If the foot inclines from either the outer or inner border, it will always rise upon loosening the base bolt, and correct alignment will be almost impossible. It will be necessary to re-machine all four feet to achieve parallelism between them.

10. Check for indicator bar shaft deflection.
    - This deflection is due to the weight of the indicator dial.
    - Mount the dial indicators on the equipment in the same manner and distance required to perform the alignment procedure.
    - Start straight up at the top of the shaft and rotate 180" down to the bottom.
    - Note the indicator readings.
    - This deflection can be corrected easily during the alignment. For example, with the indicators in the upper position on the shaft, instead of starting at 0.000 inches, mark the positive value of the deflection of the bar determined in the previous step, and then rotate the shaft 180" to the bottom. Now the indicators will read 0.000 inches.

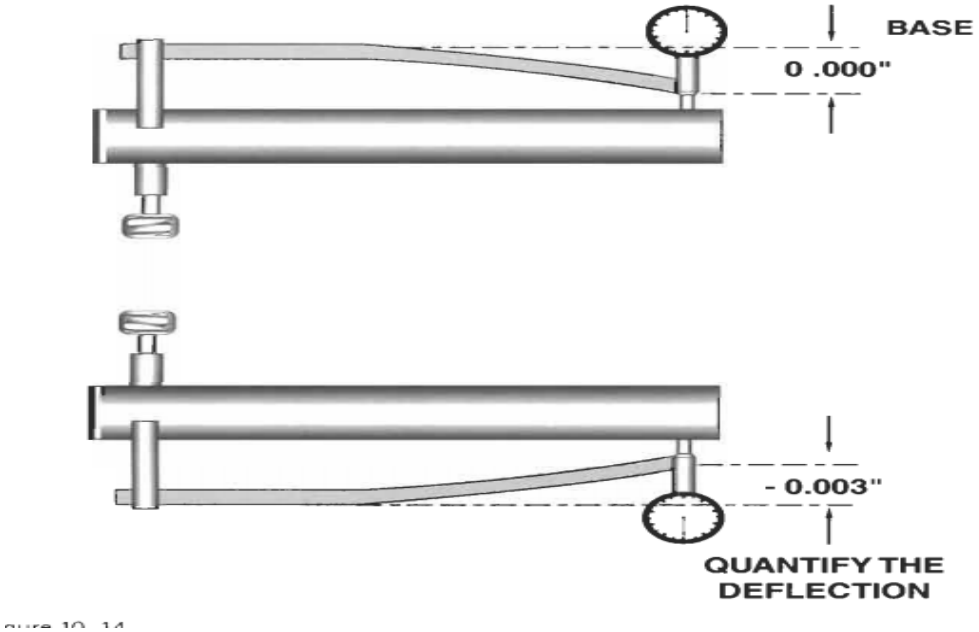


Fig. 3.9

11. Perform a Preliminary Alignment

- Bring the equipment shafts into a reasonable state of alignment with a machinist straight edge ruler and calibrated spacers before using the dial indicators. When the shafts are far out of alignment the dial indicators will make numerous revolutions causing confusion. It is much better to perform a preliminary alignment before applying the indicators.
- Double check the distance between shafts with the recommendation of the coupling manufacturer.

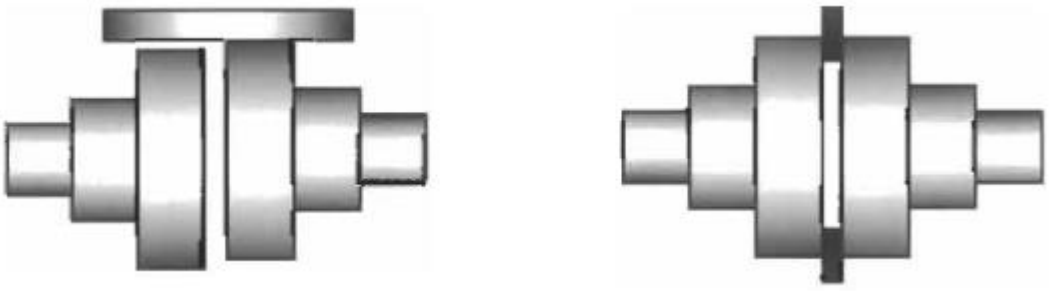


Fig 3.10

3.2 Proper pump repair alignment methods

This dial indicator is fixed to the volute mounting adapter collar of the pump and the needle is on the shaft (Figure 3.11). The shaft should be moved radially by hand (see the arrows) up and down. Note

the movement in the indicator. This is a check of the radial tolerance in the bearing. So people use the word ‘run out'. Radial deflection causes misalignment of the rotating and stationary faces of the mechanical seal. This shortens the seal life by causing drive pins and springs to wear and rub in relative motion.

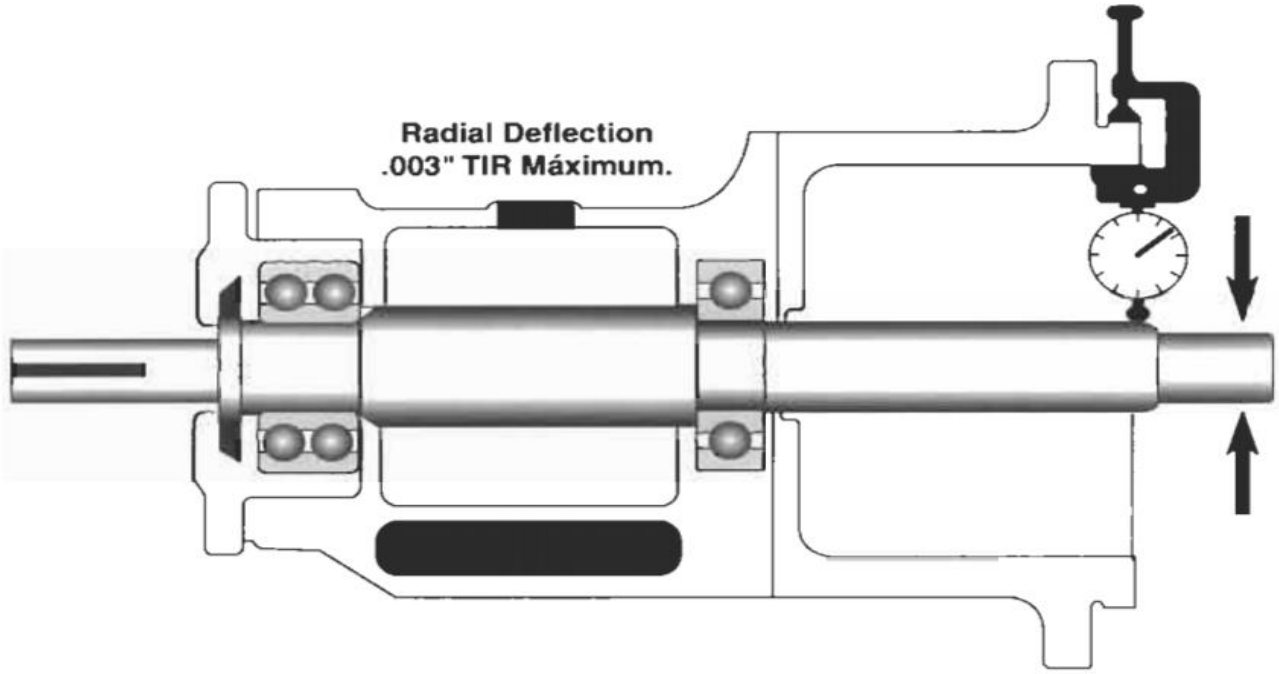


Fig 3.11

Leaving the indicator needle touching the radial diameter of the shaft, rotate the shaft by hand (Figure 3.12). This should be done with the naked shaft, and also with the shaft sleeve if the pump takes a sleeve. This reading checks the roundness and straightness of the shaft. If the haft is not round, there will be excessive vibrations and may distort the faces of the seal sacrificing its optimum life. If the shaft is not straight, the rotary face of the seal will wipe across the stationary face as it spins. This leads to premature failure from vibrations and can damage the Radial Deflection pump wear rings, and the motor and coupling. The same reading should be taken on the motor end of the shaft.

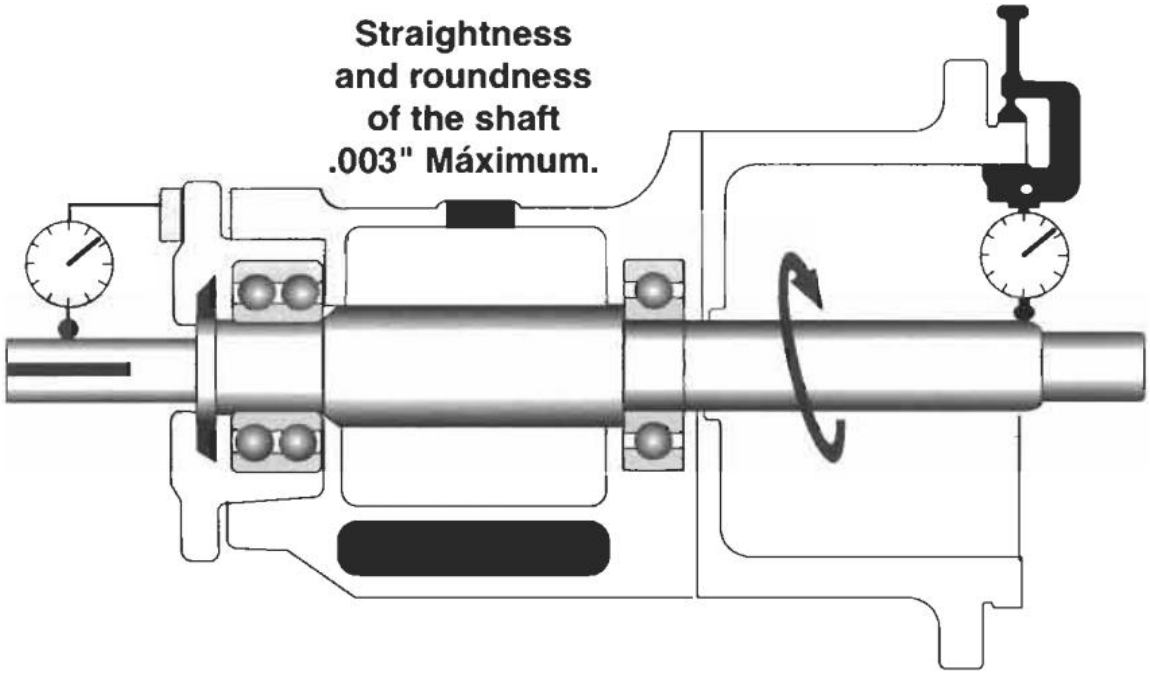


Fig 3.12

With the indicator fixed to the volute mounting collar, place the needle on the end of the shaft (Figure 3.13). Push and pull the shaft axially by hand (see the arrows). This will read the tolerance in the axial bearing. This tolerance affects the spring tension holding the faces together. If the play in the axial bearing is too loose, the movement can open or even crush the seal faces.

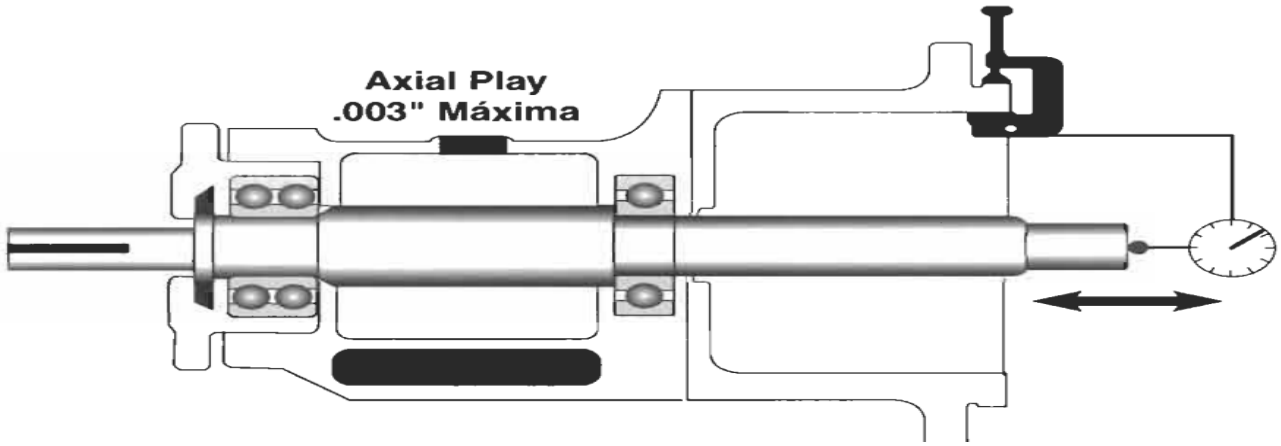


Fig 3.13

Install the pump back plate and seal chamber assembly. Mount the dial indicator on the shaft and place the needle onto the outer diameter of the lip or face of the seal chamber (Figure 3.13). An alternate method would be to place the indicator needle inside the seal chamber

bore. Rotate the shaft. This will verify that the shaft is concentric with the seal chamber bore. If it is not concentric, the seal may rub against the bore when the pump is started.

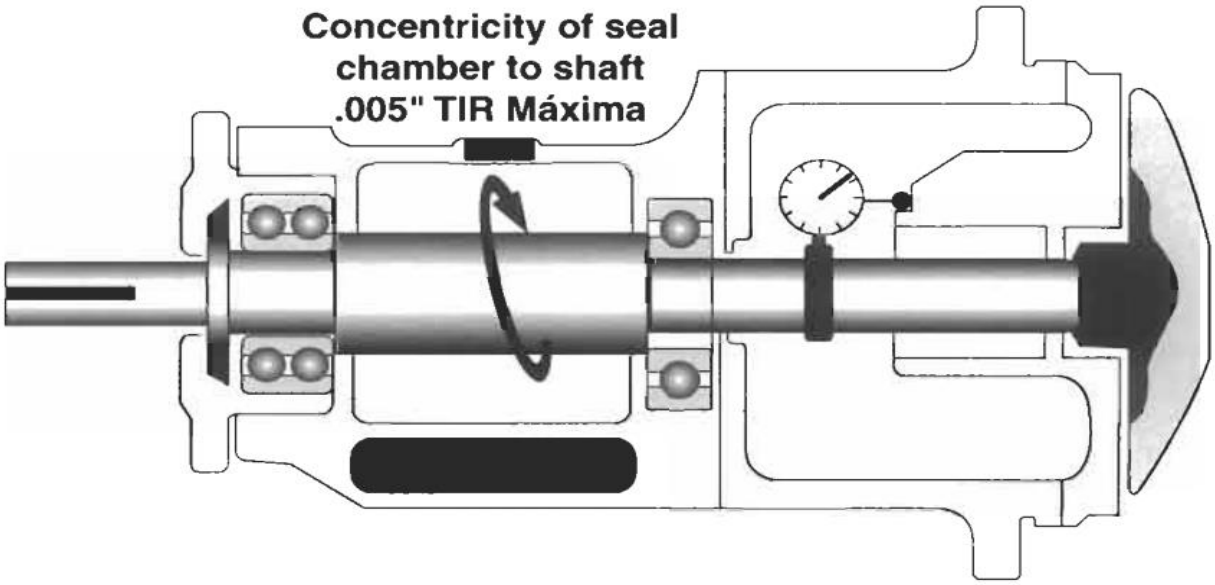


Fig 3.14

With the indicator still in this same position, place the needle onto the lip or face of the seal chamber (Figure 3.15). Rotate the shaft. This will verify the perpendicularity of the seal chamber to the shaft. If the chamber is not perpendicular to the shaft, the seal's faces and springs will have to flex twice with every revolution to maintain contact. This will lead to fretting corrosion, a damaged pump shaft or sleeve, and rapid failure of the seal.

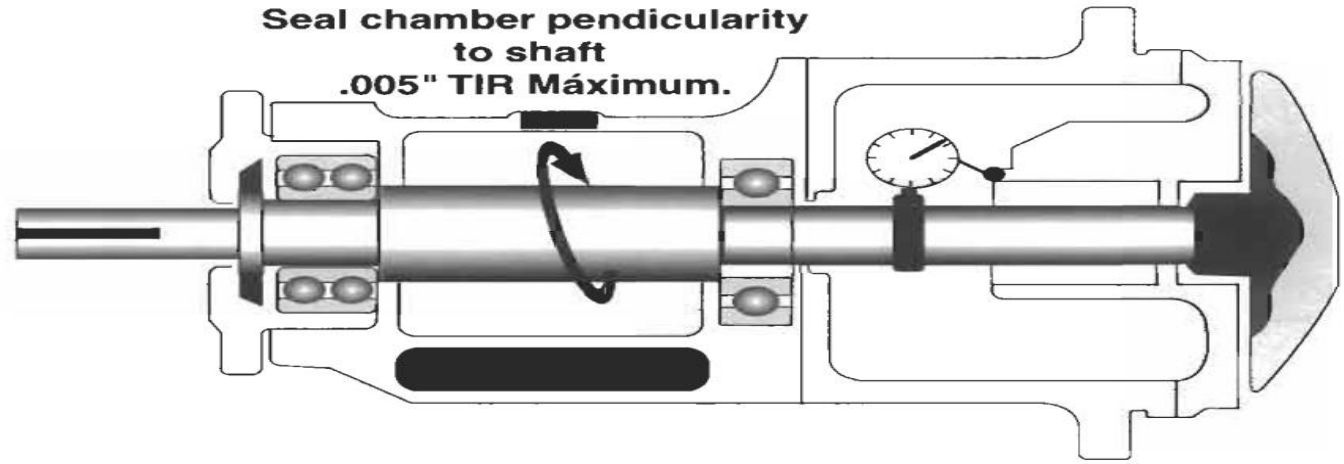


Fig3.15

3.3 Pump and motor coupling

Don’t use a flexible coupling to compensate for misalignment between the pump and motor shafts. The purpose of the flexible coupling is to compensate for temperature changes and to permit some axial movement of the shafts without interference, while they transfer energy from the motor to the pump.

There should be enough space between the coupling halves so that they don’t touch should the motor shaft move forward toward the pump. This space should also consider movement due to wear in the pump thrust bearing. The coupling manufacturer specifies the minimum separation dimension between the coupling halves. You'll need a machinist rule and thickness gauge or feeler gauge to perform a rough alignment.

Before starting the alignment procedure, disconnect the coupling halves. First, verify the rough angular alignment inserting feeler gauges at four points (90^0) around the faces between the halves. The alignment is correct when the feeler gauge distance is the same at all measured points. The rough parallel alignment is done by placing the machinist rule across both coupling rim surfaces in the upper position, lower position, and both lateral points. The parallel rough alignment is correct when the straight edge rests uniformly on both rims at all four positions. Be sure that the coupling rims are concentric with the pump and motor shafts.

Don't start the pump until after completing all the previously mentioned points, and any other specification mentioned in the operation and maintenance manual of the pump provided by the pump supplier. Not doing this could cause equipment damage and even personal injury. It might even void the pump guarantee.

Self-Check -3	Written Test

Direction III: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth one point

1. Which of the following is methods to align pump and motor shaft?
   A. Reverse Dial Indicator alignment.
   B. Rim and Face alignment.
   C. Straight Edge alignment.
   D. All
2. Which one is an implication for pump exhibiting rotary assembly imbalance (eccentric rotation)
   A. Excessive running noise.
   B. Vibration and excessive loads on the bearings
   C. Rapid wear of the coupling
   D. All
3. If the pump shaft and impeller assembly were perfectly balanced and aligned, it would rotate in a perfect orbit around the shaft centerline.
   A. True B. False

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

Answer Sheet-3

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3.

Information Sheet-4	Torqueing all fastenings

4.1 Introduction to Torqueing of fasteners

Torqueing is a measure of how much force acting on an object which causes that object to rotate. The application of preload to a fastener by the turning of the fastener's nut. Friction points should always be lubricated when using the **torque tightening** method. **Torque Tightening** and Preload

Fastener fatigue failure accounts for the majority of all fastener problems. Fatigue breaks are caused by insufficient tightening and the lack of proper preload or clamping force. This results in movement between the parts of the assembly and bending back and forth or cyclic stressing of the fastener. Eventually, cracks will progress to the point where the fastener can no longer support its designed load.

4.1.1 Fasteners for pump

Both metallic and non-metallic fasteners for water pumps are standard assembly bolts and specialized bolts, nuts and washers in a variety of suitable materials and plating's are mentioned below

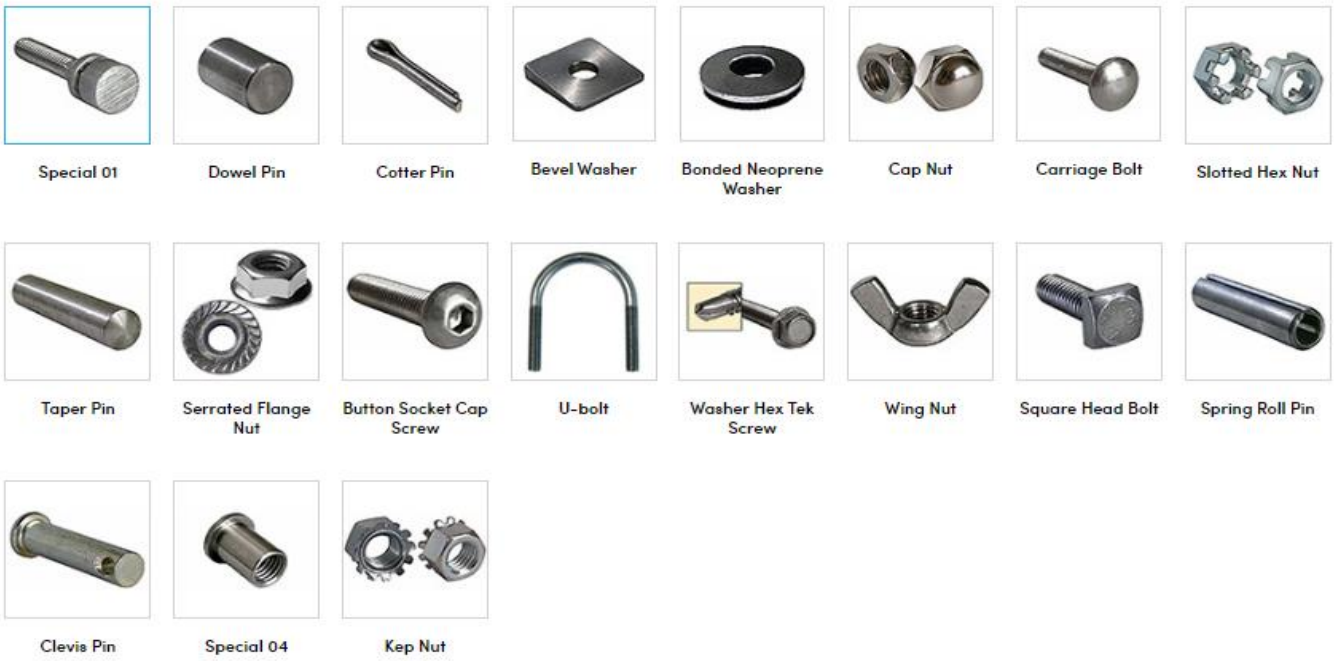


Fig 4.1 some water pump fasteners

4.1.1 Torque Tightening

- Torque Tightening is the application of preload to a fastener by the turning of the fastener's nut.

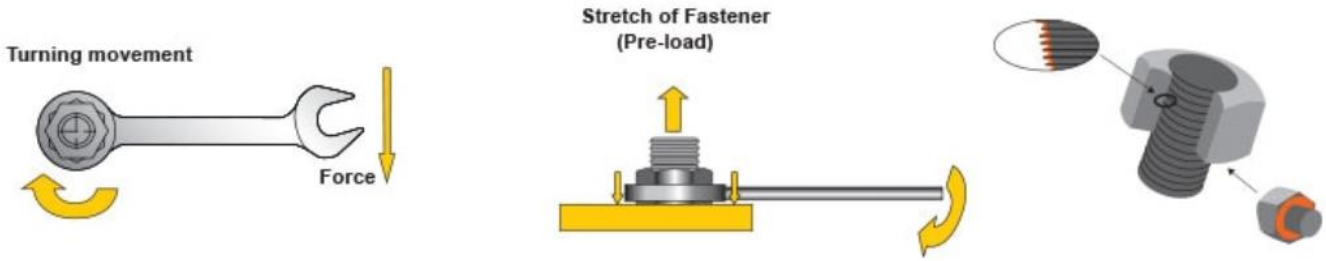


Fig4.2 how Torque Tightening applied

Friction points should always be lubricated when using the torque tightening method.

Lubrication reduces the friction during tightening, decreases bolt failure during installation and increases bolt service life. Variation in friction coefficients affect the amount of preload achieved at a specified torque. Higher friction results in less conversion of torque to preload. The value for the friction coefficient provided by the lubricant manufacturer must be known to accurately establish the required torque value.

4.1.2 Torque Procedure

When torqueing it is common to tighten only one bolt at a time, this can result in Point Loading and Load Scatter. To avoid this, torque is applied in stages following a prescribed pattern:

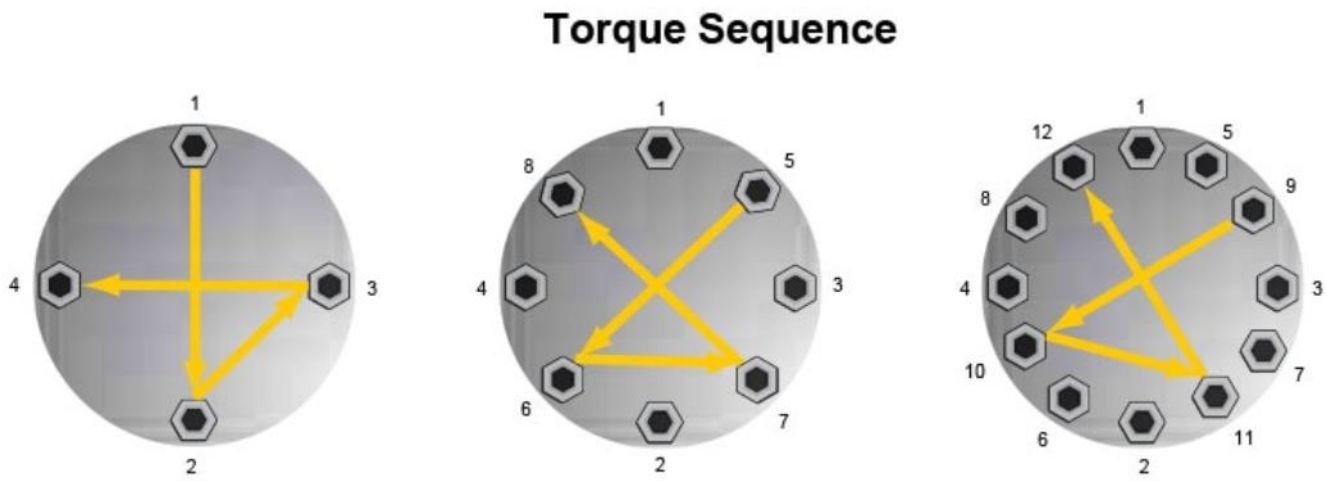


Fig 4.3 torque sequence

Step 1: Spanner tight ensuring that 2-3 threads extend above nut

Step 2: Tighten each bolt to one-third of the final required torque following the pattern as shown above.

Step 3: Increase the torque to two-thirds following the pattern shown above.

Step 4: Increase the torque to full torque following the pattern shown above.

Step 5: Perform one final pass on each bolt working clockwise from bolt 1, at the full final torque.

Self-Check -4	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth one point

1. Torqueing is a measure of how much force acting on an object which causes that object to rotate

   A. True B. False

2. _____ reduces the friction during tightening, decreases bolt failure during installation and increases bolt service life

   A. Nut B. lubrication C. painting D. wearing

Direction II: If the number shown the tighten bolt. Indicate the possible tighten procedure for the following diagram: its wight 4 points.

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

Answer Sheet-4

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____
2. _____
3. _____

Information Sheet-5	Test running, monitoring and adjusting machinery/plant and pump as required

5.1. Introduction pump operation (running) test

Normally little consideration is given to operating practices for centrifugal pumps. However Some critical practices must be followed, such as using proper start -up procedure, using proper bypass operation, and operating the pumps under stale conditions.

Start the pump

- Before starting the pump, completely open the isolating valve on the suction side of the pump and leave the isolating valve on the discharge side almost closed.
- Vent the pump during start-up by loosening the air vent screw in the pump head/cover until a steady stream of liquid runs out of the vent hole.
- Pay attention to the orientation of the vent hole to ensure that the escaping water does not cause personal injury or damage to the motor or other components.
- In hot-water installations, special attention should be paid to the risk of personal injury caused by scalding hot water.
- When the pipe work has been filled with liquid, slowly open the isolating valve on the discharge side until it is completely open.
- If the pump is fitted with a motor with an output selected on the basis of a specific maximum flow rate, the motor may be overloaded if the differential pressure is lower than anticipated.
- Check the overload by measuring the motor current consumption and comparing the value with the nominal current stated on the motor nameplate.
- In case of overload, throttle the valve on the discharge side until the motor is no longer overloaded.
- It is advisable always to measure the motor current consumption during start-up.

Note: At the moment of start, the input current of the pump motor is up to six times higher than the full load current stated on the motor nameplate.

Bypass

- The pump is not allowed to run against a closed valve as this will cause an increase in temperature/formation of steam in the pump which may cause damage to the pump.

- If there is any danger of the pump running against a closed discharge valve, a minimum liquid flow through the pump should be ensured by connecting a bypass or drain to the discharge pipe.
- The minimum flow rate must be at least 10 % of the maximum flow rate. The flow rate and head are stated on the pump nameplate.

5.2 Commissioning and start-up

- Do not start the pump until it has been filled with liquid and vented.
- When pumping drinking water, the pump should be flushed through with clean water
- before start up in order to remove any foreign matters such as preservatives, test liquid or grease.

5.2.1 Flushing the pipe system

- The pump is not designed to pump liquids containing solid particles such as pipe debris and welding slag.
- Before starting up the pump, the pipe system must be thoroughly cleaned, flushed and filled with clean water.

5.2.2 Priming

Closed systems or open systems where the liquid level is above the pump inlet:

- Close the discharge isolating valve and slowly open the isolating valve in the suction pipe, both the pump and the suction pipe should be completely filled with liquid.
- Slacken the priming plug in order to vent the pump. Once liquid runs out, tighten the priming plug.
- Pay attention to the orientation of the priming hole to ensure that the escaping water does not cause personal injury or damage to the motor or other components.
- In hot-water installations, special attention should be paid to the risk of personal injury caused by scalding hot water.

Suction operation with non-return valve

The suction pipe and the pump must be filled with liquid and vented before the pump is started.

Steps for priming

- Close the discharge isolating valve and slowly open the isolating valve in the suction pipe.
- Remove the priming plug.

- Pour liquid through the funnel until the suction pipe and the pump are completely filled with liquid.
- Fit the priming plug.
- The suction pipe may be filled and vented via the priming plug.
- Open systems where the liquid level is below the pump inlet.
- If an isolating valve is fitted on the suction side of the pump, the valve must be fully open.
- Close the discharge isolating valve and tighten the priming and drain plugs.
- Connect a manual venting pump instead of a priming device (funnel).
- A slide valve should be installed between the venting pump and the centrifugal pump inorder to protect the venting pump against excessive pressure.
- Once the slide valve at the manual venting pump has been opened, vent the suction Pipe using short, rapid pump strokes until the liquid runs out on the discharge side. Close the valve at the venting pump.

Checking the direction of rotation

The pump must be filled with liquid when checking the direction of rotation. The correct direction of rotation is shown by arrows on the pump housing. Seen from the pump end, the direction of rotation must be counter-clockwise.

Shaft seal run-in period

- The seal faces are lubricated by the pumped liquid, meaning that there may be a certain amount of leakage from the shaft seal.
- When the pump is started for the first time, or when a new shaft seal is installed, a certain run-in period is required before the leakage is reduced to an acceptable level.
- The time required for this depends on the operating conditions, i.e. every time the operating conditions change, a new run-in period will be started.
- Under normal conditions, the leaking liquid will evaporate. As a result, no leakage will be detected.
- Liquids such as kerosene will not evaporate, and drops will be visible, but this is not a shaft seal failure.

Self-Check -5	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth one point

1. Which of the following is methods to align pump and motor shaft?
   A. Reverse Dial Indicator alignment.
   E. Rim and Face alignment.
   F. Straight Edge alignment.
   G. All
2. Which one is an implication for pump exhibiting rotary assembly imbalance (eccentric rotation)
   E. Excessive running noise.
   F. Vibration and excessive loads on the bearings
   G. Rapid wear of the coupling
   H. All
3. If the pump shaft and impeller assembly were perfectly balanced and aligned, it would rotate in a perfect orbit around the shaft centerline.
   B. True B. False

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

Answer Sheet-5

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3.

Operation Sheet 1	Levelling, aligning, coupling and connecting Pump

	Torqueing all fastenings **Test running, monitoring and adjusting machinery/plant and pump as required**

Steps to Installing and checking the operation of submersible pump

Step5 Selecting required safety equipment's and tools

Step6 Checking the submersible and its control boards protected from sunshine or rain or dust and is located in appropriate area that is free from any insecure item that could inhibit operation, ensure cooling air ventilation screen are clear

Step7 Pre- installation checks

You should perform prior to install the submersible pumps.

- Ensure the parts of submersible pump and its are free from damage
- Ensure the cable free from damage

Step8 checking the Installation

- Check the control and the for heavy accumulation of dust and dirt
- Clean as necessary, they can cause an electrical hazard
- Loose fastenings /fixing, install water level sensor and fix loose connection as necessary

Step9 Checking pre operation of submersible pump

- Test the whole electrical connection by using multimeter and megger

Step10 Checking operation of submersible pump

- Connect the three phase cables to switch board input terminal and measure the input voltage
- Connect the cable of pump to switchboard through outputs of the switch bored
- Start the pump by pressing the start push button

Step11 . Checking post operation of submersible pump

- Inspecting the discharge of the water
- Interchange the two phases if there is low discharge

Step12 Clean the submersible pump area and return the necessary tools used

Operation Sheet 2	**Preparing Site for pump replacement** **Levelling, aligning, coupling and connecting Pump** **Torqueing all fastenings** **Test running, monitoring and adjusting machinery/plant and pump**

Steps to install and checking the operation of Afridev pump.

(if your college is not compatible to install these pumps go to filed and demonstrate these operation)

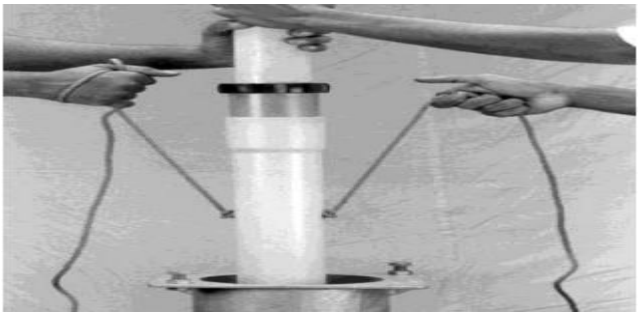
1. Selecting required safety equipment's and tools
2. Preparing of Down Hole Components. (to prepare please refer Afridev pump hand pump manual)
3. Install the Down Hole Components

   3.1 Pour an adequate amount of solvent cement into the small bowl and apply a layer of cement to interior surface of the bell-end of the suction pipe and a layer to the cylinder (or spigot) end.

   3.2 Place the end of the suction pipe on the apron and insert the cylinder in "one go" into the bell-end of the suction pipe.

   3.3. Remove any surplus solvent immediately with absorbent paper.

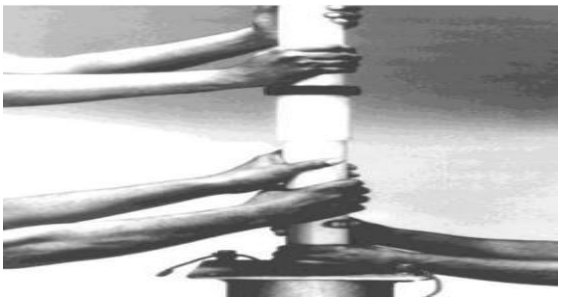
   3.4. After a curing time of at least 5 minutes, insert the suction pipe with cylinder into the pump stand and lower it so that the cylinder top is protruding by about 0.5 m. Then tighten the two ropes on the two prepared bolts on the pump stand flange.



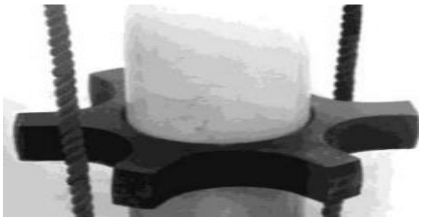
   3.5. Apply solvent cement to the inside of the bell-end with the smaller brush and at the same time the application to the pipe end of the protruding pipe should be made with the bigger brush.

   3.6. Bring the riser pipe into position and push the bell-end immediately "in one go" over the protruding pipe until its end position

3.7. Remove any surplus of solvent cement immediately with absorbent paper. Allow the joint to set at least for minutes before loosening the ropes for lowering the pipe into the position for the next joint



3.8. When lowering the pipe, place the rope into two opposite grooves of the centralizer's and never support or hold the pipe by hand (support only by the two rope ends) since the weight of the pipe should not be taken by the newly made joints.



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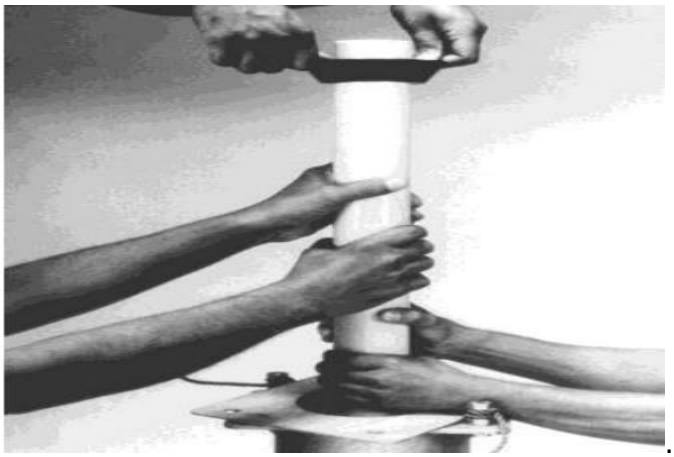
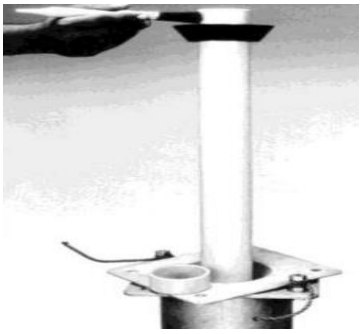
3.9. As soon as the protruding pipe is in the required position for the next joint, secure it by fixing the rope to the bolts on the pump stand flange

3.10. As soon as the last pipe is lowered, the steel cone is inserted and laid to the top flange of the pump stand.



3.11. Clean the protruding pipe end again with cleaning fluid and as soon as it is dry, apply solvent cement to the pipe

3.12. Allow the jointed top sleeve to set for at least 20 minutes, before the rubber cone and the steel cone are adjusted



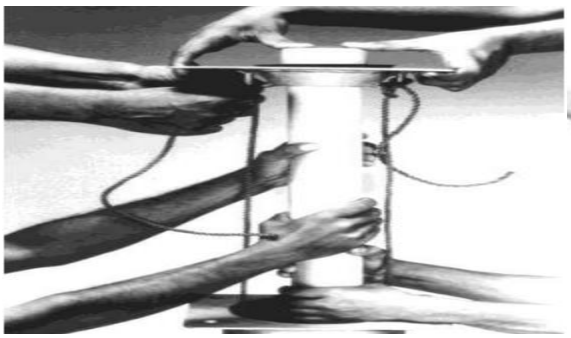
3.13. After the setting time, one or two persons should lift the complete rising main assembly by the steel cone, while a third person starts to connect each rope ends to the eyes of the steel cone with two or three securing knots

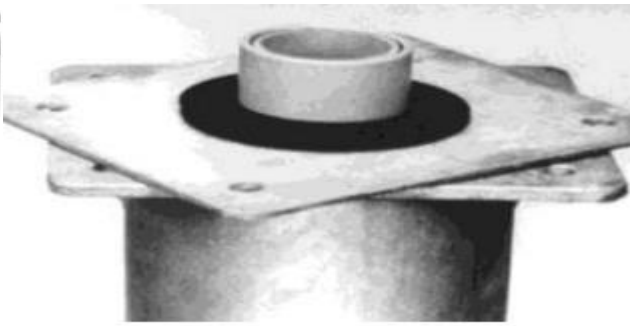
3.14. Cut the rope ends, but leave at least 2 m excess length for each rope end (this makes it easy for connecting another rope for easy removal, in case the rising main assembly needs to be pulled out for repair Insert the rope ends into the pipe of the pump stand or the casing pipe, lower the whole rising main assembly onto the pump stand flange and remove the bolts from the flange.

3.15. Move the steel cone so that all four holes of the cone plate and the pump stand flange are matching.

3.16. Cover the hole of the newly installed rising main pipe to prevent playing children from dropping dirt or stones into the well and let the joints cure for at least 12 hours

.

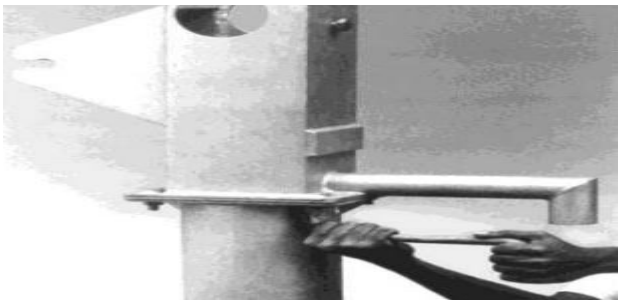




4. Installing of Above Ground Components of Afridev hand pump

4.1 Install pump head on stand assembly and tighten bolts fully

4.2 Attach plunger rod with the plunger and check that the bobbin and the cup seal (or U-seal) are in the correct position

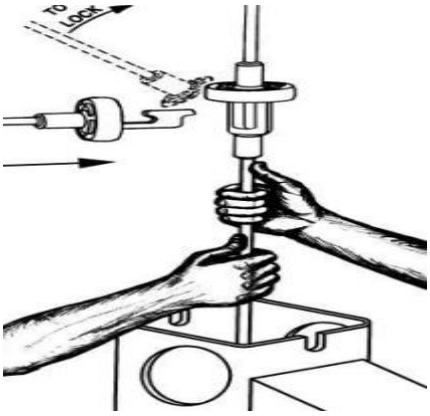


4.3 Connect first pump rod to the plunger rod and insert it into the rising main pipe

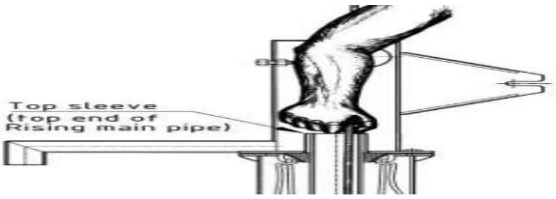
4.4 Connect all following pump rods and make sure that all connections are tightened.

4.5 Pump rods with Hooks & Eye Connections are made by inserting the hooks horizontally into the eyes.

4.6 Connect all pump rods as described until the plunger is sitting on top of the foot valve.



4.7 Determine at what point the top rod needs to be cut, so that the pump rod assembly has required length



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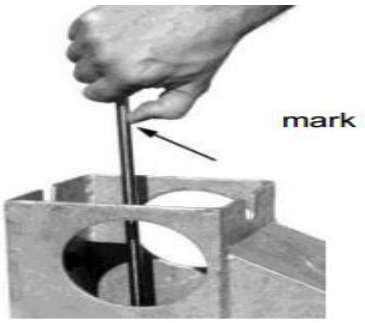
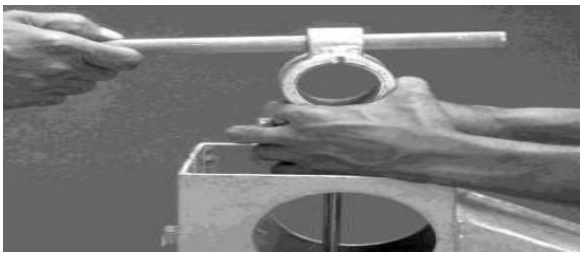
4.8 As soon as the hand is outside the pump head, mark the exact position of the thumb with a permanent marker

4.9 After marking, lift the pump rod assembly as far as to the next connection and disconnect the top rod



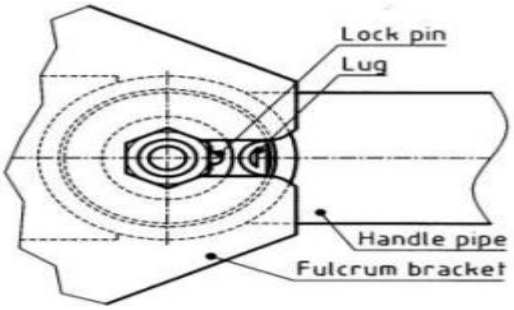
4.10 Slip on flapper on the pumper and fix the rod hanger assembly. Make sure that the rod is inserted to the full extent and that the hexagonal bolt is tightened securely

4.11 Insert the spanner handle into the bush on top of the rod hanger and lower the complete pump rod assembly.

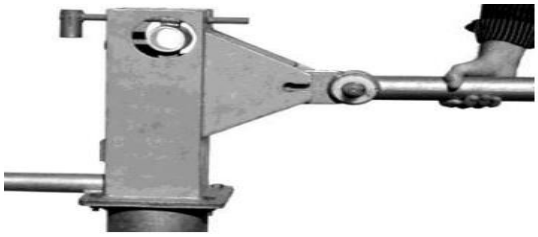


4.12 Prior to connecting the handle front assembly, assemble one bearing set with the fulcrum pin and insert it into the fulcrum housing of the handle front.

4.13 Adjust the lock pins of the fulcrum assembly and the two lugs of the bearing bush inner to the correct position



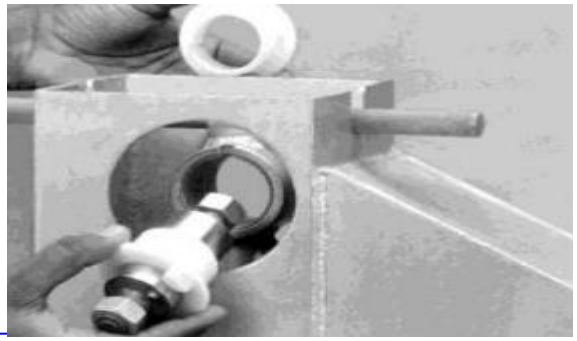
4.14 Insert the handle front fully and fasten the special nuts of the fulcrum pin by hand.

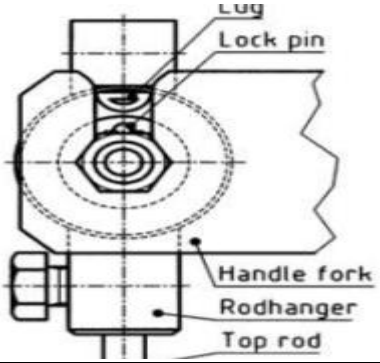


.

4.15 Assemble one bearing set with the rod hanger pin and insert it into the rod hanger assembly.

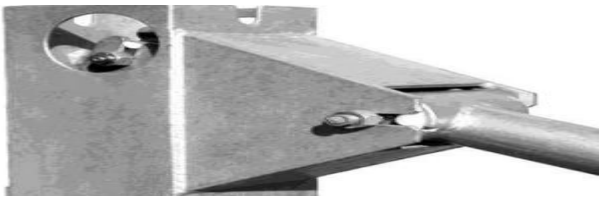
4.16 Adjust the lock pins of the rod hanger assembly and the two lugs of the bearing bush inner to the correct position





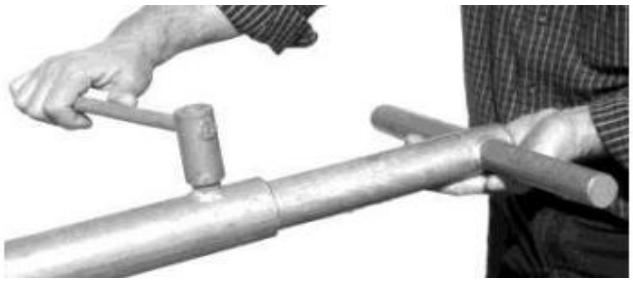
4.17 If additional adjustments of lugs and pins are required during insertion into the slots of the handle front, please take care of your fingers.

4.18 Push down the handle to its lowest position and remove the spanner handle from the lug of the rod hanger assembly.



4.19 Prior to fastening the nuts of the fulcrum- and hanger pin make sure that they are in correct position. Tighten nuts securely

4.20 Insert the handle rear assembly into the handle front assembly and tighten adjustment bolt securely



4.21 Operate the handle till the water flows out of the spout.

4.22 Initially the first water might be turbid and smelling from chorine, but after 15 to 30 minutes of operation it should become clear

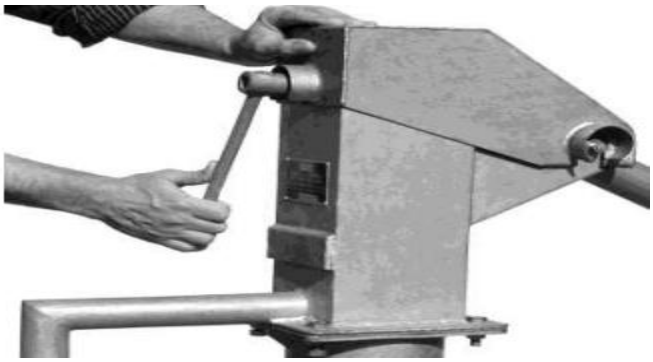
4.23 Now the following checks should be carried out:

a) All nuts and bolts are well secured,

b) Effort required to operate the pump is normal,

c) No leakage in the rising main (wait for 5 minutes to see whether water in the rising main assembly is receding,

4.24 Fix the cover and tighten the cover bolt and check the discharge.



5. Clean the Afridev pump area and return the necessary tools used.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Giving the necessary equipment's and PPEs you are required to perform the following tasks within 6 hours.

Task 1. Install and check the operation of submersible pump

Task 2. Install and check the operation of Afridev pump (hand pump)

Instruction Sheet-5	**Learning Guide #29: Complete the work**

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

- Completing work and notifying appropriate personnel
- Clearing of waste, cleaning, restoring and securing work area
- Maintaining and storing Plant, tools and equipment
- Finalizing Work completion details

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 –**

- Complete work and notify appropriate personnel in accordance with site/enterprise requirements
- Clear of waste, clean, restore and secure work area in accordance with site/enterprise procedures
- Maintain and store Plant, tools and equipment in accordance with site/enterprise procedures
- Finalize Work completion details in accordance with site/enterprise procedures

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 4”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3, and 4” in each information sheets on pages,163,165, 168 and 171.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, on pages 172.and do the LAP Test on 173”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG

Information Sheet-1	**Completing work and notifying appropriate personnel**

1.1 Introduction to Completing work and notifying

Record keeping: Keep equipment and maintenance records for each pump and drive assembly. The method used is prescribed by local command. In general, records will contain entries for routine maintenance (lubrication, equipment checks, etc.), as well as scheduled overhauls and nonscheduled repairs. A description of the work done, the date, and the name of the person doing the work are minimum entries. Since a pump's condition is best evaluated by comparing its current performance to its original performance, a record of flow, pressure, pump speed, amperage, and other test data, determined immediately following installation, is recommended

Maintenance Records

To ensure accurate recording of all the maintenance operation performed on a given pump, prepare a record card. Factors those should be included in the record cards are Pump serial number, Pump Size, pump Type, Manufacturer, Order Number, date of Shipped, rated Conditions, Staffing box data, Construction materials, and Drive Types. Keep this record handy because it is extremely important during maintenance and when ordering spare parts.

Table 1.1 Pump Record Card

<table>
<tr><td>Serial no: ---------
Size ----------
Type----------</td><td>Pump Manufacturer ----------</td><td>Mfr. Order no: ----
Order No: ----
Item No: ---------</td><td>Date of shipped: --/--/---
Date Receive: --/--/--</td></tr>
<tr><td>Rate Condition
M^3/hr----------
Discharge Pressure----
Suction head: -------
Delivery head: -------
Impeller Diameter: ---------
Impeller Type: --------</td><td colspan="2">Shaft Diameter: ----------
Shaft sleeve Diameter: ------
Packing size: ----------
Packing manufacturer: ------</td><td>Pump Materials
Casing----------
Casing rings----------
Impeller----------
Shaft----------
Shaft sleeve----------
Bearing materials----------
Gasket thickness----------
Wearing ring clearance----------</td></tr>
<tr><td colspan="4">Driver Type: ---------- Mfr: ---------- Seri: ---------- Specific Type: ---------</td></tr>
<tr><td colspan="4">Hp-------- RPm: ----------</td></tr>
<tr><td colspan="4">Volts: ---------- Phase: ---------- Cycle: ----------</td></tr>
<tr><td colspan="4">Room. Temperature: From --------to----------</td></tr>
</table>

ITT PRO SERVICE CENTERS

MULTI-STAGE HORIZONTAL SPLIT CASE DIFFUSER PUMP

JOB #	79798	CUSTOMER:	CAC
DATE:	May 4/2016	INSPECTED BY:	Jeff Rich

PUMP DATA

MFG:		MODEL:	
SIZE:		# OF STAGES:	

DISASSEMBLY **CASE INSPECTION**

Suction nozzle coated in scale

What is the condition of the parting face: Good

Warpage when checked with straight edge:

Mic All Bore Sizes:

Stuffing Box Thrust End At Mechanical Seal Register:	3.998"	Stuffing Box Coupling End At Mech Seal Register:	3.997"
Thrust End Seal Gland Register OD:	3.990"	Coupling End Seal Gland Register OD:	3.992"
Clearance:	0.008"	Clearance:	0.005"
Throttle Bushing Fits Cplg End:	3.238"	Throttle Bushing Fit Thrust End:	3.347"

Diffuser/Channel Ring Fits:

STAGE		STAGE	
1	5.246"	7	5.249"
2	5.237"	8	5.247"
3	5.245"	9	5.753"
4	5.248"	10	
5	5.250"	11	
6	5.243"	12	

Make Bushings for Boring Bar and Check Bore for Runout: [ ] GOOD [ ] BAD

Check all bores, including stuffing boxes for any signs of washing or cracking.
Any suspicious signs?

Fig1.1 sample for detailed Inspection Form

ITT PRO SERVICE CENTERS

MULTI-STAGE HORIZONTAL SPLIT CASE DIFFUSER PUMP

DISASSEMBLY	**BEARING HOUSINGS - RADIAL END**						
BEARING TYPE:							
Babbit Lined?	Yes		No	X	If Yes is it Split?		
	OD SIZE				ID SIZE:		
Ball Bearing?	Yes	X	No:		If Yes, what is the BRG #	SKF 6309/C3 423059X	
Does it have a temperature probe?	No						
What size is the bearing fit in the bore of the housings?	3.938"						
Is housing a split type?	No						
If split, did it have a gasket?	N/A				Thickness of Gasket?	N/A	
Condition of Faces:							
What is the condition of the face where it bolts to the pump case?	Good						
Does it use an oil slinger ring?	Yes				If so, how many?	1	
Condition of rings:	Good						
What is the condition of the end cover?	Good						
			Reuse	X	Rework		
Are there gaskets?			Sizes:				
What is the condition of the deflectors?							
NOTES:	New split line gasket will be manufactured						

Fig 1.2 sample for pump bearing detailed inspection form

Self-Check -1	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two point

1. Which of the following does maintenance contain?
   A. entries for routine maintenance
   B. scheduled overhauls
   C. nonscheduled repairs
   D. All
2. Maintenance record card are important to ensure the accurate recording of all the maintenance operation performed on a given pump.
   A. True
   B. False
3. Keep factory maintenance record card handy because it is extremely important during maintenance and when ordering spare parts.
   A. True
   B. False

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

Answer Sheet-2

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. ____.
2. _____ .
3. _____

Information Sheet-2	Clearing of waste, cleaning, restoring and securing work area

2.1 Introduction clearing, restoring and securing work area

Work area clearing is the process of removing rubble, debris and, in some cases, other materials which have been deposited due to an incident, or event making an area unsafe or unusable. The ultimate aim of work site clearing is to return of the site or area to its former condition or use prior to the incident

After maintain and replace pump, care should be taken in clearing, restoring and the securing work area:

- Workers should know that the job is not complete until the tools are cleaned and stored in a designated location.
- Used tools and equipment's should be collected and cleaned properly according to organizational cleaning procedures
- Clear tools and equipment from work area.
- Locking storage cabinets and restricting access to storage areas will prevent unauthorized handling of stored items and minimize the possibility of theft
- Store reusable materials and equipment in an appropriate location.
- Restore the work areas to a safe condition in accordance with agreed requirements and schedules

Cleaning

- Clean the tools immediately after use.
- Wash the tools using water. A wire brush may be useful to loosen the soil stuck to the blades.
- Avoid the risk of spreading pathogens while the tools are being cleaned.
- Coat the blades with light oil like WD-40 on areas prone to rust.

Storage

- Store tools in a dry, sheltered environment. Place tools on a rack for easy safety and easy access.
- Place similar tools close together so that workers can see easily the available tool

Self-Check -2	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two point

4. Which of the following is work area clearing is the process?
   A. removing rubble, debris around work area
   B. removing materials which making an area unsafe or unusable.
   C. Removing accessory tools around work area
   D. All
5. Reusable materials and equipment should store in an appropriate location.
   A. True
   B. False
6. Work areas should restore in a safe condition in accordance with agreed requirements and schedules
   A. True
   B. False

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

Answer Sheet-2

Name: _____Date: _____

Score = _____

Rating: _____

Answers

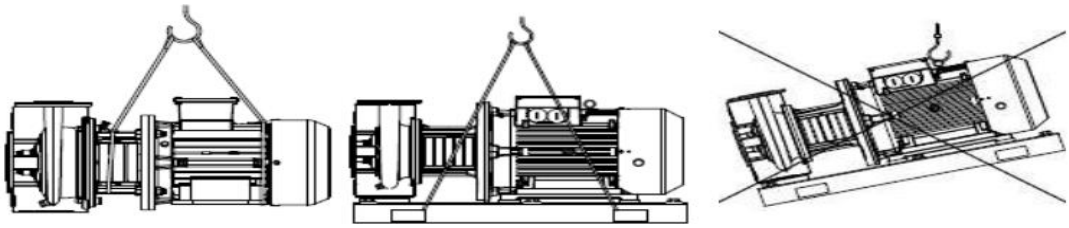
1. ____.
2. _____ .
3. _____

Information Sheet-3	Maintain and store Plant, tools and equipment

3.1 Introduction to maintain and store plant, tools and equipment

3.1.1 Handling and storage

- Pump motors as from 4 kW are lifted with base plate & lifting eye must not be used for lifting the entire pump unit.
- See figure below, pumps should be lifted by means of nylon straps and shackles or a hook as shown in figures below:



Correct lifting of pump without base frame | Correct lifting of pump with base frame | Incorrect lifting of pump

Fig 3.1 pump handling way

- The engineer(technician) must inspect the equipment on delivery and make sure that it is stored in such a way that corrosion and damage are avoided.
- If more than six months will pass before the equipment is put into operation, please consider applying a suitable corrosion inhibitor to the internal pump parts.
- Ensure that the corrosion inhibitor used does not affect the rubber parts with which it comes into contact.
- Ensure that the corrosion inhibitor can easily be removed.
- To prevent water, dust, etc. from entering the pump, all openings must be kept covered until the pipes are fitted.
- Mechanical shaft seals are precision components. If the mechanical shaft seal of a recently installed pump fails, this will normally happen within the first few hours of operation.
- The main cause of such failures is improper installation of the shaft seals and/or mishandling of the pump during installation.
- During transport, the pump must be fastened securely to prevent damage to the shaft and seal caused by excessive vibrations and knocks.
- The pump must not be lifted by means of the shaft.
- The pump should be sited in a well-ventilated, but frost-free location.

- When pumping hot liquids, care should be taken to ensure that persons cannot accidentally come into contact with hot surfaces.
- For inspection and repair, allow suitable clearances for pump or motor removal.

3.1.2 Maintain tools and equipment

An effective maintenance program should aim to minimize these effects by keeping equipment clean and dry, keeping connections tight and minimizing friction.

Tools that are unsafe/faulty can be categorized in to two: those having minor faults such as loose handle, rusted hinges, damaged blade, bent ends & dirt edges, dismantled casing, missing screws etc… and those fully damaged include broken teeth, broken blade, tool with missing parts, worn tools, burned elements, open circuits inside the tool, frayed or damaged flexible cords etc...

The method of identifying faulty and functional tools is done either by visual inspection or by performing different tests using test instruments

Tools and equipment are visually inspected before use and electrically tested by a competent person as necessary Visual checks are carried out as follows:

Tools/appliance

- On/off switch is working correctly
- No signs of damage to casing
- No loose parts or missing screws
- Live parts are properly guarded so as not to be inadvertently accessible
- Ensure equipment is disconnected when not in use

Maintenance of pump tools and equipment

- Keep metal blades of all tools sharp and well-oiled.
- Check for loose and worn out parts on tools regularly, and replace if necessary.
- Identify damaged tools and store them in a designated location to allow either the supervisor or maintenance person to arrange for their repair

Self-Check -3	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two point.

1. Tools and equipment are visually inspected before use and electrically tested by a competent person as necessary Visual checks are carried out as follows:

A. True B. False

2. Among the following tool faulty which one is categorized as fully damaged

A. loose handle, B. rusted hinges, C. damaged blade D. open circuits inside the tool,

3. Tools and equipment must inspect before use.

A. True B. False

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

Answer Sheet-3

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3.

Information Sheet-4	Finalize Work completion details

4.1 Maintenance Forms and Records

A written record of pump inspections, tests, exercising, operation and repairs must be maintained on the premises and be available for review by the fire inspector on request. This record must, at a minimum, include: the date of the report, name(s) of the person(s) providing the service, identification of unsatisfactory conditions and corrective action taken (including parts replaced), and any testing of repairs recommended by the manufacturer.

4.2 Record Keeping

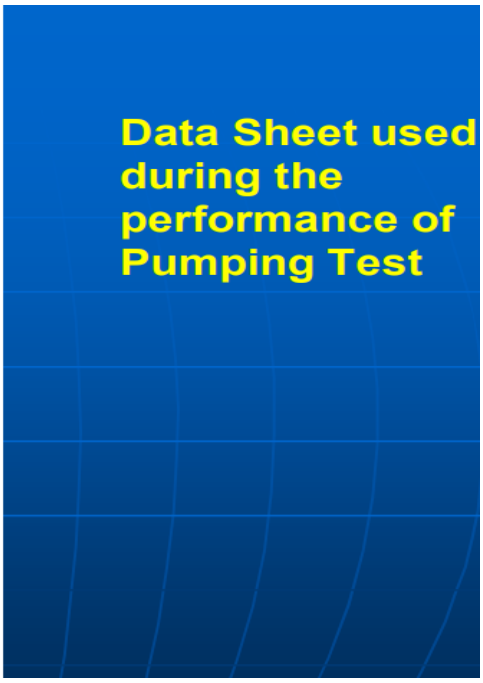
Recording and retaining maintenance information is an integral part of the operator's job. However, **data gathering and retention** is also important in the maintenance operation. It allows:

- Prediction of maintenance efforts.
- Better condition assessments for overhaul and replacement.
- Support for departmental staff and resource requests.
- Retaining records is important for legal, historical, budgetary, and benchmarking purposes.
- Regulatory agencies may require documentation of equipment maintenance.
- Documentation of maintenance functions can serve as legal proof, as needed.
- Tracking information can indicate historical patterns. These patterns can point to areas that are less than cost-effective, faulty, or time- and labor-intensive.
- Management can refer to retained records to plan, improve, or manage budgets.
- Benchmarking is a process that compares the plant's performance to industry standards; records help find areas of excellence and weakness in an organization.

PUMPING TEST DATA SHEET

Project: ----------
Name of abstraction well: ----------
Distance from observation well: ----------
Well Depth: ----------Well Diameter: ----------
Date of test: Start: ----------Finish: ----------
Depth of pump: ----------S.W.L: ----------
Remarks: ----------

Date	Actual time	Elapsed time (t) (min)	Depth to water table (m)	Draw Down (m)	Q (m^3/hr)	Remarks



4.3 Work completion details

plant and maintenance records

Plant and maintenance records are the set of documentation that constitute of written statements (or table format) of overall intentions and directions as defined or given by the organization. It contains the entire information from the stage of receiving maintains (or inspecting) to knowing of the maintenance result.

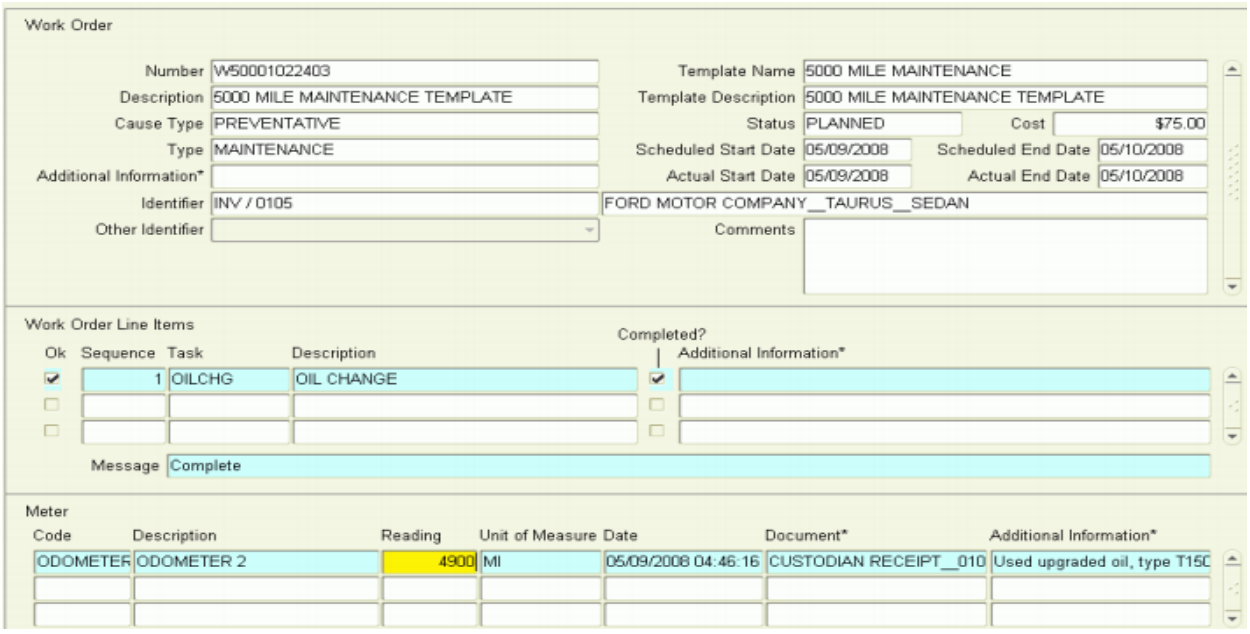


Fig 4.1 sample maintenance record

Self-Check -4	Written Test

Direction I: Choose the best answer for the following questions. Use the Answer sheet provided in the next page: Each question worth two point.

1. Plant and maintenance records contains the entire information from the stage of receiving maintains (or inspecting) to knowing of the maintenance result.

   A. true B. False

2. Plant and maintenance records are the set of documentation about maintenance.

   A. True B. False

3. Retain maintenance records is important for the maintenance work as it request.

   A. True B. False

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

Answer Sheet-4

Name: _____Date: _____

Score = _____

Rating: _____

Answers

1. _____ 2. _____ 3.

Operation Sheet 1	Completing work and notifying appropriate personnel

	Finalize Work completion details

Steps to prepare pump maintenance forms and records

1. Prepare necessary tools and equipment
2. Identify the pump
3. Fill the following Pump Record Card

Serial no: --------- Size ---------- Type----------	Pump Manufacturer ----------	Mfr. Order no: ---- Order No: ---- Item No: ---------	Date of shipped: --/--/--- Date Receive: --/--/--
Rate Condition M^3/hr---------- Discharge Pressure---- Suction head: ------- Delivery head: ------- Impeller Diameter: -------- Impeller Type: ------	Shaft Diameter: ---------- Shaft sleeve Diameter: ---------- Packing size: ---------- Packing manufacturer: ----------	Pump Materials Casing---------- Casing rings---------- Impeller---------- Shaft---------- Shaft sleeve---------- Bearing materials---------- Gasket thickness---------- Wearing ring clearance----------	
Driver Type: ---------- Mfr: ---------- Seri: ---------- Specific Type: ---------			
Hp-------- RPm: ----------			
Volts: ---------- Phase: ---------- Cycle: ----------			
Room. Temperature: From --------to----------			

4.clean and return necessary tools and equipment

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Giving the necessary equipment's and PPEs you are required to perform the following tasks within 2 hours.

Task 1. Prepare pump maintenance forms and records

List of Reference Materials

1. K.L. Narayana, P. Kandiah “Textbook of Machine Drawing”, New age international publishers “third edition
2. R. K Rajput “Textbook of Fluid Mechanics and Hydraulic Mechanics” S. chand & company ltd publishers first edition 1998
3. Amanuel& B. Tolossa D. “Textbook basic technical drawing for grade 12ics” kuraz international publisher 2003E.C
4. R. Keith and R. Higgines “Maintenance engineering hand book” Mc Graw -hill Company. six edition 2002
5. L. Bachus and A Custodio “Know and Understand Centrifugal Pumps” Published by Elsevier Ltd 2003
6. Maharajpur “Maintenance & trouble shooting of centrifugal mono block pump set”
7. https://www.pumpfundamentals.com/centrifugal_pump.htm
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