TECH A·V
LEARNING AIDS

BASIC CENTRIFUGAL PUMPS

(BCP)

Learner Guide

TABLE OF CONTENTS

CONTACT DETAILS:
https://techav.co.za
info@techav.co.za

BASIC CENTRIFUGAL PUMPS (BCP-1)

INTRODUCTION

This programme provides you with the necessary resource information for you to learn about typical centrifugal pumps commonly installed in a wide variety of industries.

THE RESOURCE MATERIAL CONSISTS OF

1) **This workbook;** which contains verbal and pictorial information about pumps.
2) **A video programme** illustrating and explaining facts about centrifugal pumps.

Optional resources (not supplied with this set):

1) Sectioned model pumps.
2) Manufacturers operating and maintenance manuals.

NOTE: You will be assisted and tested by your Instructor or Course Controller.

HOW TO USE THIS PROGRAMME

Please read this page **carefully** before continuing.

INSTRUCTIONS FOR LEARNING

1) READ

- The overall objective.
- The competency test/criterion test.

NOTE: If after reading the competency test instructions you feel that you **already** know how to do it then ask your Instructor or Course Controller to allow you to attempt it.

2) BEGIN EACH TASK BY

- Reading the task objective.
- Reading the resource notes (where applicable).
- View the video programme following any verbal or on-screen instructions.
- Then complete the necessary self-check exercises in this book.

3) PRACTICE

- Where applicable, practice any work suggested.

4) CONSULT

- Your Course Controller / Instructor is always available to assist you.
- If you have any queries or are not sure what to do then **ASK.**

OVERALL OBJECTIVE OF THIS PROGRAMME
BCP -1

Upon completion of this programme you will be able to:

- Explain the general working principles of centrifugal pumps.
- Identify principle components in typical pumps.
- Identify various types of pumps (centrifugal).
- Explain and identify typical shaft seals/packings.
- Explain and identify typical pumping systems.
- Explain the concept of "head".
- Describe planned maintenance procedures.

  CRITERIA (How well it must be done).
- Within the parameters set out as per the competency test evaluation.

CONDITIONS

- Given the necessary resources in your training centre, trade school or workplace.
- With the assistance of an INSTRUCTOR or a COURSE CONTROLLER.

TASK NO.1
PUMP OVERVIEW

TASK OBJECTIVE

Upon completion of this section you will be able to explain the general working principles of typical centrifugal pumps.

INSTRUCTIONS

1) Watch the video (BCP-1).
2) Stop the video at the first "discussion" logo.
3) Complete the self-test exercise that follows.

TASK NO.1
SELF CHECK EXERCISE

Answer the following questions:

QUESTION 1:
What "force" is generated on moving bodies when they are spun (rotated)?
ANS:_____

QUESTION 2:
When liquid is spun, or swirled around what is created at the rotating centre of its mass?
ANS:_____

QUESTION 3:
What part of a centrifugal pump is used for "energising" the liquid?
ANS:_____

QUESTION 4:
What causes liquid to be drawn up (sucked) into a pump?
ANS:_____

TASK NO.1
SELF CHECK ANSWERS

1) Centrifugal Force.
2) Allow pressure area or vortex.
3) The impeller.
4) The vortex (i.e. low pressure).

TASK NO.2
PUMP PARTS

TASK OBJECTIVE

Upon completion of this section you will be able to identify the principle component parts, and their functions, in a simple end suction type centrifugal pump.

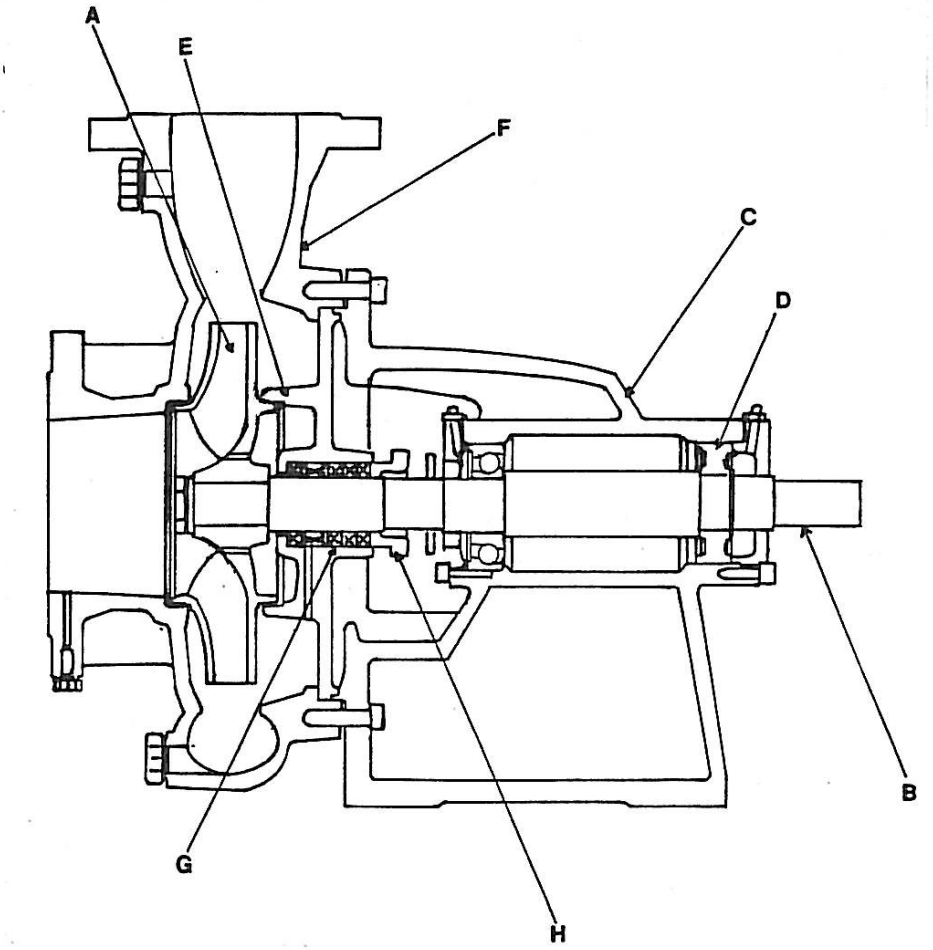
INSTRUCTIONS

1) Continue viewing the video (BCP-1).
2) Stop video at Discussion Break No 2.
3) Complete the self-test exercise that follows.

TASK NO.2
SELF CHECK EXERCISE

QUESTION 1:

Label the parts indicated on the diagram below.



ANSWERS

A = _____ E = _____

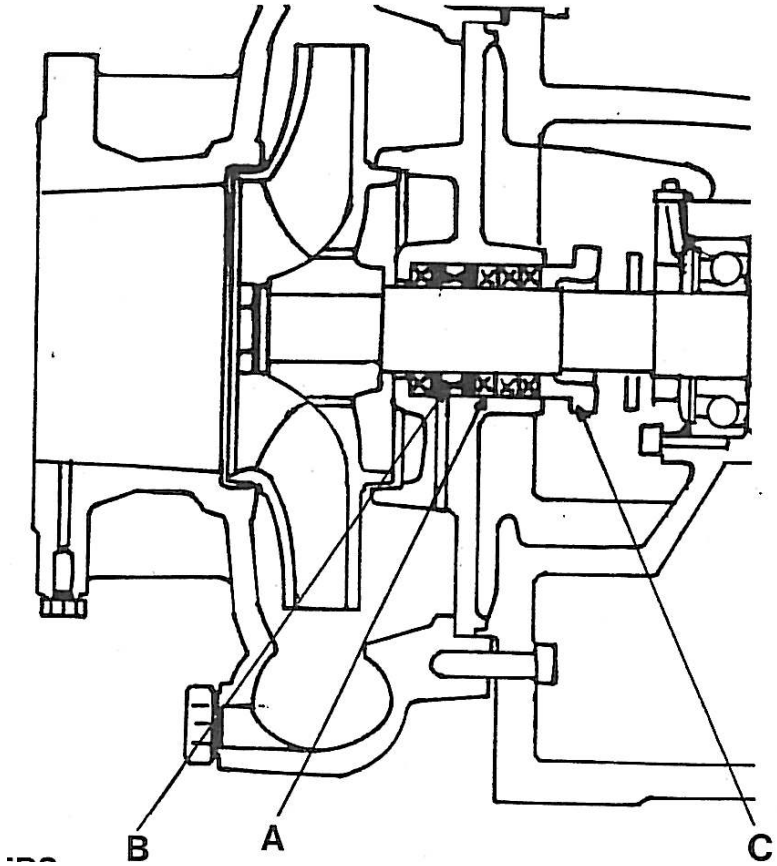
B = _____ F = _____

C = _____ G = _____

D = _____ H = _____

QUESTION 2:

Label the parts of the gland packing illustrated below.



ANSWERS:

A = _____

B = _____

C = _____

TASK NO.2
SELF CHECK ANSWERS

QUESTION 1

A) Impeller.
B) Impeller shaft .
C) Bearing bracket.
D) Bearings.
E) Gland cover.
F) Volute casing.
G) Stuffing box.
H) Gland follower.

QUESTION 2

A) Packing rings.
B) Lantern ring.
C) Gland follower.

TASK NO.3
PUMP FEATURES

TASK OBJECTIVE

Upon completion of this section you will be able to identify and describe important features on a typical centrifugal single stage (end suction) pump.

INSTRUCTIONS

1) Watch the video sections BCP-1.
2) Complete the self-test exercise that follows.

TASK NO.3
SELF CHECK EXERCISE

Answer the following questions:

QUESTION 1:
Why do clearances between the impeller and the pump casing have to be very small?
ANS:_____

QUESTION 2:
What is the purpose of a "wear ring"?
ANS:_____

QUESTION 3:
The "packing rings" are intended to do what?
ANS:_____
_____

QUESTION 4:
What is the purpose of a "wear sleeve"?
ANS:_____
_____

QUESTION 5:
Why is fluid, or water, intentionally introduced to the packing rings?
ANS:_____
_____

QUESTION 6:
At what part of the gland area is water or fluid introduced to the packings?
ANS:_____
_____

QUESTION 7:
It is normal and desirable to observe fluid leakage past the gland packings, why is this?
ANS:_____
_____

QUESTION 8:
How can one control the leakage rate?
ANS:_____
_____

QUESTION 9:

What can be used to replace soft packings when leakage may be an unsafe condition?

ANS:_____

_____

QUESTION 10:

What are the main areas for attention, from a maintenance point of view on centrifugal pumps?

ANS : _____

_____

TASK NO.3
SELF CHECK ANSWERS

1) To reduce energy/power loss to the liquid OR to reduce internal leakage.
2) To provide a replaceable means of reducing the impeller clearances after wear has occurred.
3) To prevent the excessive water leakage and the entrance of AIR into the hydraulic area.
4) To protect the impeller shaft and provide a replaceable wear surface to the packing rings.
5) To provide **better** air exclusion and to lubricate.
6) Via the lantern ring.
7) This ensures that **air** is not entering past the shaft.
8) By tightening or loosening the gland nuts by small amounts.
9) A **mechanical** seal.
10) Wear rings -wear sleeves and packings.

TASK NO.4
PUMP TYPES

TASK OBJECTIVE

Upon completion of this section you will be able to identify commonly utilised centrifugal pump types.

INSTRUCTIONS

1) Watch the video programme BCP-1.
2) Complete the self-test exercise that follows.

TASK NO.4
SELF CHECK EXERCISE

Answer the following questions:

QUESTION 1:

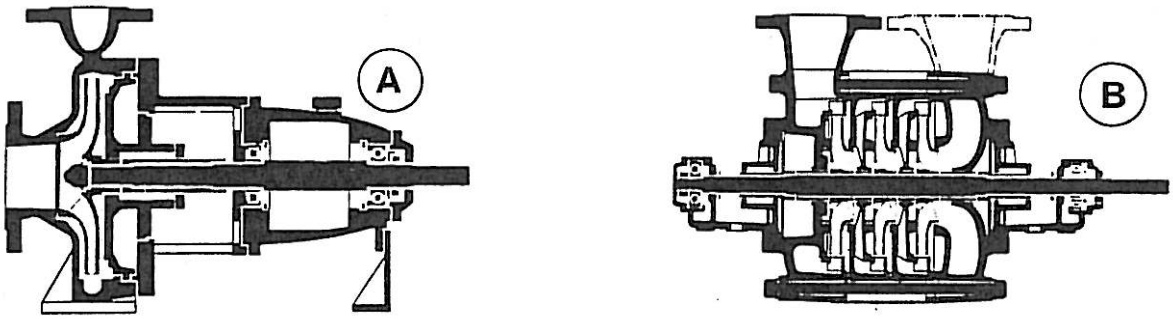
What are the two main classifications of centrifugal pumps?

A :_____

B :_____

QUESTION 2:

Label (name) the pump types illustrated below.

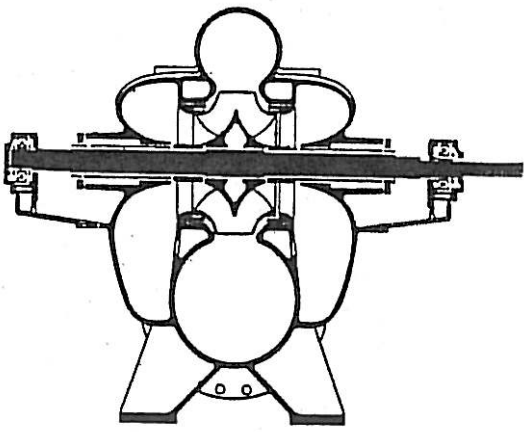


A :_____

B :_____

QUESTION 3:

What type of pump is illustrated below?



ANS:_____

QUESTION 4:

What feature of a "horizontal split" type pump differs from that of an end entry type pump?

ANS:_____

_____

QUESTION 5:

What does the term "pump set" mean?

ANS:_____

_____

QUESTION 6:

What important factors have to be considered when a pump is coupled to its drive unit?

ANS:_____

_____

TASK NO.4
SELF CHECK ANSWERS

1) A: Single stage.
   B: Multi stage.
2) A: Single stage.
   B: Multi stage.
3) Horizontal split .
4) Fluid enters the impeller from both sides i.e. double entry.
5) The fully assembled pump unit on its base.
6) That both pump and motor (drive unit) are aligned perfectly.

TASK NO.5
INSTALLATIONS / PRINCIPLES

TASK OBJECTIVE

Upon completion of this section you will be able to describe basic pumping principles in an open type system.

INSTRUCTIONS

1) Watch video programme BCP-1.
2) Complete the self-check exercise that follows.

TASK NO.5
SELF CHECK EXERCISE

Answer the questions that follow:

QUESTION 1:
What does the term "suction lift" or "static suction mean?
ANS:_____
_____

QUESTION 2:
What is meant by "static delivery head"?
ANS:_____
_____

QUESTION 3:
In a simple open system, what constitutes the "total static head"?
ANS:_____
_____

QUESTION 4:
What is meant by "flooded suction" or "suction head"?
ANS:_____
_____

QUESTION 5:
What conditions can result in frictional losses in any pumping system?
ANS:_____
_____

QUESTION 6:
What does the expression "Priming a pump" mean?
ANS:_____
_____

QUESTION 7:
What device prevents fluid running back to the supply when the pump is switched off?
ANS:_____
_____

QUESTION 8:
What will occur if a pump is run without being primed?
ANS:_____
_____

TASK NO.5
SELF CHECK ANSWERS

1) That the pump has to draw its liquid from below the level of the pump itself.
2) The height to which the liquid has to be lifted above the level of the pump.
3) The distance between the surface level of the supply liquid and the top of the discharge pipe.
4) The supply liquid is above the level of the pump.
5) Pipe walls, pipe bends and valves.
6) Ensuring that the suction line and the pump casing is full of liquid before a pump is started.
7) A foot valve, or non-return valve.
8) Extensive internal pump damage.

TASK NO.6
MAINTENANCE

TASK OBJECTIVES

Upon completion of this section of the programme you will be able to describe the important aspects of maintenance, including pump shut down and start up procedures.

INSTRUCTIONS

1) Watch the video programme BCP-1.
2) Complete the exercise that follows.
3) Read the Resource Information notes following the self-check exercise.

TASK NO.6
SELF CHECK EXERCISE

Answer the following questions:

QUESTION 1:
As a general rule, maintenance must be done on a pump only, when?
ANS:_____
_____

QUESTION 2:
Which valve should be closed before shutting down a pump?
ANS:_____
_____

QUESTION 3:
How do you prevent someone from starting the pump whilst you are working on it?
ANS:_____
_____

QUESTION 4:
Which important fasteners should be checked for security on the pump?
ANS: 1) _____
2) _____
3) _____

QUESTION 5:
What item should be kept clean and free of debris?
ANS:_____
_____

QUESTION 6:
What lubrication checks need be made?
ANS:_____
_____

QUESTION 7:
Describe the correct way to start a pump.
ANS:_____
_____

QUESTION 8:
What daily checks are made to a pump?
ANS: 1) _____
2) _____
3) _____

QUESTION 9:

What type of fluid was a centrifugal pump originally designed to work in?

ANS:_____

_____

QUESTION 10:

What can quickly wear a pump out?

ANS:_____

_____

_____

CHECK YOUR ANSWERS ON THE FOLLOWING PAGE

NOTE: *THIS COMPLETES THE VIDEO INPUT SECTION. PLEASE READ THE RESOURCE NOTES ON THE PAGES FOLLOWING SELF CHECK EXERCISE NO.6. THEN ATTEMPT THE CRITERION TEST*

TASK NO.6
SELF CHECK ANSWERS

1) When it has been shut down.
2) The delivery valve, or the outlet valve.
3) By LOCKING OUT the main switch.
4) 1) Base bolts.
   2) Pipe flanges.
   3) Drive coupling.
5) The suction line strainer.
6) Oil or grease levels of the shaft bearings.
7) Switch on pump, keep delivery valve closed, open delivery valve fully.
8) 1) Pipe joints for leaks.
   2) Gland packing for leakage rate.
   3) Vibration checks.
9) Clean water.
10) Pumping of liquids with abrasives such as mud or slurry.

The following notes are included as additional information and should be read to supplement the input provided by the video programme.

1) SAFETY

As with any industrial plant and machinery pumps can present a safety hazard. The following safety rules should be applied whenever you perform any maintenance tasks.

1.1 Always shut a pump down and lock out the main motor switch before starting work on it.

1.2 Always replace any safety guards over the motor and coupling area before restarting.

1.3 Always close the delivery valve first before shutting down the pump.

1.4 NEVER shut down a factory pump without the express permission of, or by INSTRUCTION from, a supervisor.

1.5 When working with heated liquids or corrosive liquids always wear the necessary safety clothing ego rubber or asbestos gloves, goggles, aprons and respiratory filter as applicable.

1.6 Never close a suction line valve when the pump is operating.

2) MAINTENANCE OF SOFT SEAL PACKINGS

2.1 SELECTION OF CORRECT MATERIAL

Many products exist on the market that could be used as packing rings. The golden rule to follow is to "abide by the pump manufacturers recommendation".

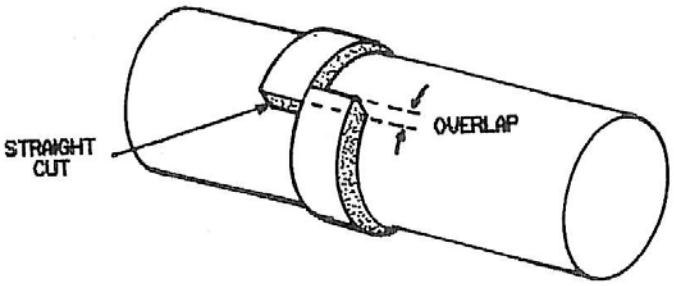
If the wrong packing is selected there is a danger that it will be too hard and thereby cause damage to the shaft or wear sleeve. It may not be compatible with the pumped liquid and thereby be destroyed and permit excess leakage.

2.2 FITTING OF PACKINGS

The procedure for replacing soft packings in pumps is very similar to that of gate and globe valves stem packing (see Tech AV programme "Valves and Valve Maintenance").

Care should be taken to ensure that old packing rings are removed fully. Thoroughly clean the stuffing box cavity. Further ensure that the lantern ring is not blocked or clogged.

Cut the new rings after first wrapping a section around the shaft. Mark the ring so that a slight overlap is included (approx. 2 mm).



NOTE: Sulzer recommend that butts should be cut square; not at a 45 degree angle as with valve stem packings.

Note how many rings were removed and from where. There may be one or more behind the lantern. Replace rings in the exact same order as they were removed.
Stagger the butt joints at about 120 degrees.

Ensure that the gland follower has room to enter the stuffing box bore after the last packing has been installed.

2.3 RUNNING IN NEW PACKINGS

Don't over tighten the gland nuts in fact it's better to finger tighten them initially. Ensure that the pump can turn freely, by hand without binding.

NOTE: If binding occurs it may be due to crimped packing rings (i.e. have been cut too long), or worse from a bent or eccentric shaft.

Run the pump under normal operating conditions and allow free leakage to occur past the packings for about 10 minutes.

Tighten the gland nuts at 10 minute intervals. Do this evenly by one sixth (i.e. one flat) of a turn only. Repeat until the leakage has been reduced to the acceptable amount.

Check at regular intervals, for the first hour or two, that overheating does not occur at the stuffing box.

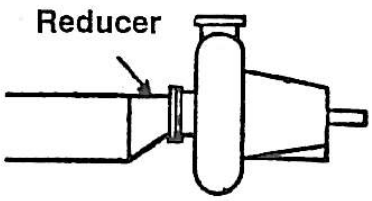
NOTE: Where external water feed is used to the packings pressurise the gland until water is seen to leak before running the pump.

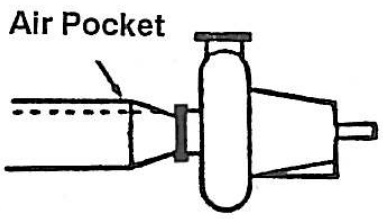
3) PIPE WORK

As a general rule the pipe work attached to and from any pump set has been designed and installed by the pump supplier or plant engineers. A few tips are included here in order that a plant fitter or operator becomes aware of certain important factors that could affect maintenance procedures.

3.1 PIPE INSTALLATIONS

In order to maintain maximum pump efficiency it is common practice to install a suction side pipe that is a size larger in diameter than the intake of the pump. A reducer connection is then used to adapt the pipe to the pump. The reducer must be fitted in such a way that the tapered edge (sloping edge) is placed at the bottom (see sketch) . Should the reducer be fitted upside down then there is a great risk of air being drawn into the pump, caused by the formation of an "air pocket".

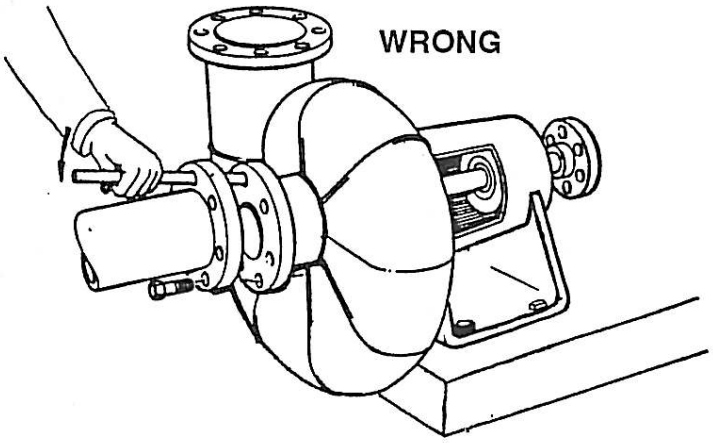




CORRECTLY INSTALLED **INCORRECTLY INSTALLED**

2.4 PIPE SUPPORTS

Any pipe connected to a pump will place strain (tension) onto the pump casing by virtue of its weight / mass. Pipe brackets are installed to bear the mass thereby eliminating the possibility of distorting and cracking pump casings. Never remove the brackets except for purposes of renewing the pipe work. If, when reinstalling a pump set, the pipes do not align to the pump flanges then do not force the alignment as this will create heavy stress loads upon the casing. Instead arrange to raise or lower the set by 'shimming', alternatively arrange for the modification of the pipe work.
The sketch below illustrates the incorrect procedure - which is commonly performed.



Acknowledgement to JOHN CRANE (PTY) Ltd

4) GENERAL MAINTENANCE TIPS

From many years of experience in the field, artisans have discovered that problems arising during maintenance operations can be avoided, or at least minimised, by following certain basic rules:

Use the correct tool for the job -improvising will inevitably result in more damage, and more

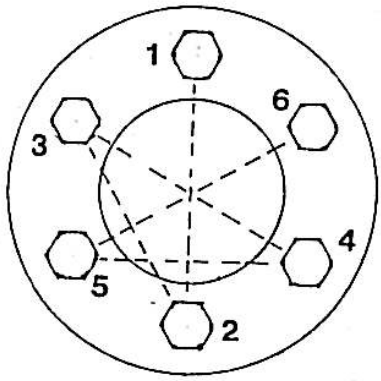
work!

Before connecting any pipes, valves etc. check inside both connections to ensure that you have not left any nuts, bolts, tools or any other objects that could be sucked into the pump and cause damage.

Lubricate all fasteners (e.g. flange nuts, bolts, screws, etc.) with an anti-seize compound before installing.

Ensure that joint facings are perfectly clean and free of old pieces of adhering joint material before placing new joints/ packings.

Tighten fasteners evenly, especially on flanges and couplings. The rule to follow (generally) is to "cross tighten" in a star or "diagonal" pattern. Do this in progressive stages -i.e. don't tighten too tightly on the first round. This technique will avoid the risk of buckling, overstress and leakage.



TYPICAL TIGHTENING SEQUENCE
(FLANGE, COUPLING, TIE-BOLTS ETC.)

Always fit **new** gaskets, seals and '0' rings. Don't refit used sealers, the money "saved" by this miserly practice is most often "lost" due to **repeat** repair procedures.

Use **clean** lubricants. Ensure that grease or oil is dispensed from clean containers. Uncovered oil drums or grease buckets attract dirt and dust which will find its way into bearings.

Clean away dirt and grime from filler caps or grease nipples **BEFORE** opening or applying the grease gun. Many bearings fail owing to the neglect of this simple practice.

The last tip we would like to emphasise is one that we call the **"last resort"**, but in fact should be the first. An old artisan quotes: "When everything you've tried has failed... read the manual!"

It is the advice of Sulzer engineers that pumps will last longer, do the job better and ultimately return greater profits if they are installed and maintained in the manner described through the operators guides or manuals supplied with every pump.

SUGGESTED FURTHER READING:

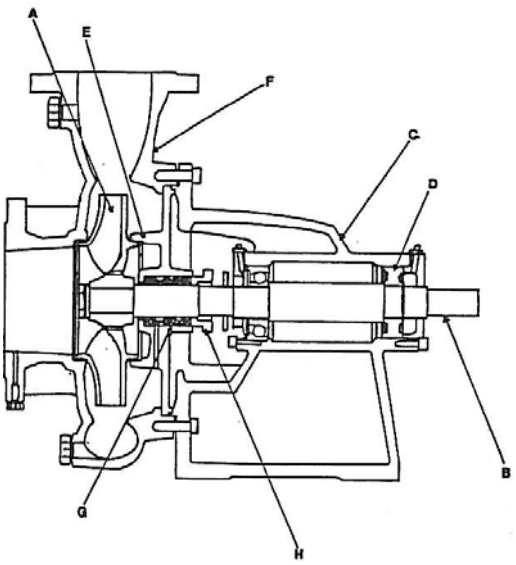
"Pumps -Principles and Practice"

(First Edition)Published by K Myles Associates (Pty) Ltd
P 0 Box 2212, Northcliff, 2115, Republic of South Africa
ISBN 0-620-12854-2N1.

INSTRUCTIONS

The following questions should be answered without reference to any study aids.

	YES	NO
QUESTION 1: **What is the primary purpose of a centrifugal pump?** ANS:_____ _____	○	○
QUESTION 2: **What two functions are performed by the impeller?** ANS:_____ _____	○	○
QUESTION 3: **Label the part names indicated on the pump illustrated below.** **ANSWERS** A = _____ B = _____ C = _____ D = _____ E = _____ F = _____ G = _____ H = _____	○	○



	YES	NO
QUESTION 4: **What is the purpose of a "wear ring"?** ANS:_____ _____	○	○
QUESTION 5: **What do packing rings do?** ANS:_____ _____	○	○
QUESTION 6: **What is used, on some pumps, to prevent the packing rings from damaging the impeller shaft?** ANS:_____ _____	○	○
QUESTION 7: **Why is it necessary to ensure that fluid or water is present at the gland?** ANS:_____ _____	○	○
QUESTION 8: **What is the function of a LANTERN ring?** ANS:_____ _____	○	○
QUESTION 9: **What can sometimes be used instead of soft packings?** ANS:_____ _____	○	○
QUESTION 10: **What classification (i.e. type) of pump has only one impeller and casing?** ANS:_____ _____	○	○
QUESTION 11: **What type of pump has a " double entry" impeller?** ANS:_____ _____	○	○

	YES	NO
QUESTION 12: **What important factor must be considered when a pump is coupled to its drive unit?** ANS:_____ _____	○	○
QUESTION 13: **What is "SUCTION LIFT" or "STATIC SUCTION"?** ANS:_____ _____	○	○
QUESTION 14: **What is the term given to the height, above pump level, that the liquid has to be raised?** ANS:_____ _____	○	○
QUESTION 15: **What does the term "FLOODED SUCTION" mean?** ANS:_____ _____	○	○
QUESTION 16: **What features in a pump system can increase friction losses?** ANS:_____ _____	○	○
QUESTION 17: **What is "SUCTION LIFT" or "STATIC SUCTION"?** ANS:_____ _____	○	○
QUESTION 18: **What function does a "foot valve" perform?** ANS:_____ _____	○	○

	YES	NO
QUESTION 19: **When shutting down a pump, what should be done before switching the power off?** ANS:_____ _____	○	○
QUESTION 20: **What must be done to prevent accidental starting of a pump whilst you are working on it?** ANS:_____ _____	○	○
QUESTION 21: **Describe how to correctly start up a pump?** ANS:_____ _____	○	○
QUESTION 22: **What parts of a pump will become damaged or worn owing to abrasive materials in the pumped fluid?** ANS:_____ _____	○	○

CHECKED AND MARKED BY: _____

CRITERION OBTAINED: YES / NO ☐ ☐

Notes

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

SINGLE STAGE END SUCTION PUMPS (BCP-2)

INTRODUCTION

This programme provides you with the necessary resource information for you to:

- Learn the principal parts and functions of a typical single-stage, end suction centrifugal pump of volute casing design.
- Dismantle a pump (procedural).
- Reassemble a pump (procedural).

THE RESOURCE MATERIAL CONSISTS OF

- This workbook.
- A video programme illustrating and demonstrating facts and procedures (Video BCP-2).

Optional resources (not supplied with Tech AV set):

- Sectioned or model pump.
- Wall chart (parts list).

NOTE: You will be assisted and tested by your Instructor of Course Controller during the practical phase of instruction.

HOW TO USE THIS PROGRAMME

Please read this page **carefully** before continuing:

INSTRUCTIONS FOR LEARNING

READ the overall objective on the next page. Then, if you consider that you can already perform the procedures outlined, ask your Course Controller to allow you to attempt the Criterion Test.

IF NOT, THEN Begin the programme at Task No.1.

- Read the task objective.
- Where applicable read the resource notes.
- View the video programme following any verbal or on-screen instructions.
- Complete any self check exercises or practical work as per the task.

INSTRUCTIONS

NOTE: Your Course Controller or Instructor is always available to assist you. If you have problems or are not sure how to go about the job ASK.

OVERALL OBJECTIVE OF THIS PROGRAMME
BCP-2

UPON COMPLETION OF THIS PROGRAMME YOU WILL BE ABLE TO

A) Describe by name the principal components and sections of a typical single stage, end suction centrifugal pump.
B) Apply the correct procedures for dismantling such a pump.
C) Describe an inspection procedure.
D) Apply correct procedures for assembling such a pump.

CRITERIA (How well the job is to be done?)

- According to the procedures recommended and demonstrated in the video programme.

CONDITIONS

- Given the necessary resources of a typical training centre.
- Given a pump of the correct type.
- Under the guidance of an Instructor or Course Controller.

TASK NO.1
PUMP PARTS/COMPONENTS

TASK OBJECTIVE

Upon completion of this section you will be able to: Identify by name the major components of and "end suction" type, single-stage pump.

INSTRUCTIONS

1) Watch the video.
2) Stop the video at the first discussion/music break.
3) Complete the self-test exercise on the following page.

TASK NO.1
SELF CHECK EXERCISE

Answer the following questions:

QUESTION 1:
What does the 'hydraulic unit' of a pump refer to?
ANS:_____
_____

QUESTION 2:
What does the 'shaft/bearing unit' comprise of?
ANS:_____
_____

QUESTION 3:
What 'classification' of bearings must be fitted to a pump (i.e. a ball or a roller type)?
ANS:_____
_____

QUESTION 4:
What does the 'shaft/seal unit' comprise of?
ANS:_____
_____

TASK NO.1
SELF CHECK ANSWERS

1) The casing (or volute), and an impeller.
2) The "bearing bracket", bearings and shaft.
3) C3.
4) Packing rings, lantern ring and gland or gland follower.

RESOURCE NOTES

The actual pumps depicted in the videos are **typical** of many single-stage end suction pumps. However, certain pump details may vary depending on the manufacturer.

Pumps are often 'custom built' for specific purposes or to the customer's requirements. It is important that you obtain the manufacturers operators guide, repair manual or service bulletins to assist you during maintenance operations.

TASK NO.2
DISMANTLING PROCEDURE

TASK OBJECTIVE

Upon completion of this section you will be able to dismantle a typical end suction single-stage centrifugal pump.

INSTRUCTIONS

1) Continue viewing video to the next visual/music prompt.
2) Perform the suggested work on self-evaluation exercise (next page).

TASK NO.2
SELF CHECK EXERCISE

INSTRUCTIONS

1) Following the demonstration of the video, dismantle a pump of a similar type in your training centre workshop or own work station.
2) Layout all parts neatly for inspection purposes.

NOTES

As the pump you work on may not have the exact same features, fasteners etc. as the pump demonstrated in the video it is suggested that you **first** read through the work manual for the pump in question.

It may be necessary to apply a little heat to the **centre** of the impeller using a heating torch (not a cutting torch) in order to 'crack the bite' of the impeller boss to shaft.

CAUTION: DO NOT HEAT EXCESSIVELY.

Some impellers may require the use of a 'puller'. Exercise care with pullers to avoid damage to the impeller nut threads on the shaft.

TASK NO.2
SELF EVALUATION

Check the criteria below and indicate with a tick (√) in the YES or NO column.

ITEM	CRITERIA	YES	NO
PEPARATION	Was the pump cleaned before dismantling?		
	Was work surface clean?		
	All tools etc. collected?	◯	◯
PROCEDURES	Did you use correct sized spanners etc.?		
	Were "jacking screws" used on bearing bracket?		
	Was impeller removed without damage.		
	Was soft hammer used for striking?		
	Are all parts neatly laid out for inspection?	◯	◯
	TOTAL		

HAVE YOUR INSTRUCTOR OR COURSE CONTROLLER CHECK YOUR WORK.
COURSE CONTROLLER SIGN: _____
DATE: _____

PROCEED TO TASK NO.3 ONCE THIS TASK HAS BEEN SIGNED OFF.

TASK NO.3
PARTS INSPECTION & ASSEMBLY

TASK OBJECTIVE

Upon completion of this section of the programme you will be able to make an inspection of the parts laid out, and then reassemble the pump.

INSTRUCTIONS

1) Continue viewing the video to the next visual/music break.
2) Read the 'resource notes' on the following page.
3) Perform the suggested work on self-evaluation exercise following the resource notes.

INSPECTION

At this level of training you are not expected to make detailed diagnoses of problems or damage. Simply inspect **all** the pumps parts for signs of **obvious** damage or wear.

As a general rule pumps of the size and type shown in the video are usually discarded after a few years service because their replacement is cheaper than major repair. However, this is not to say that they should **never** be dismantled. Often the pump is dismantled in-situ (on its set) for purposes of cleaning, impeller replacement or for other reasons.

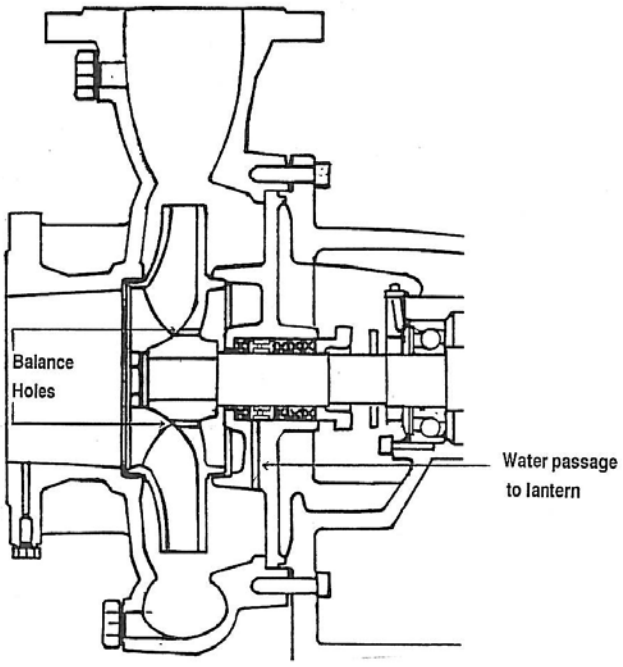
Pumps supplied without "wear rings", or wear sleeves, can be modified to have such items installed, thus providing a few more months, or years, of service. Such operations are performed by "pump reconditioning experts" and should not be attempted by inexperienced persons.

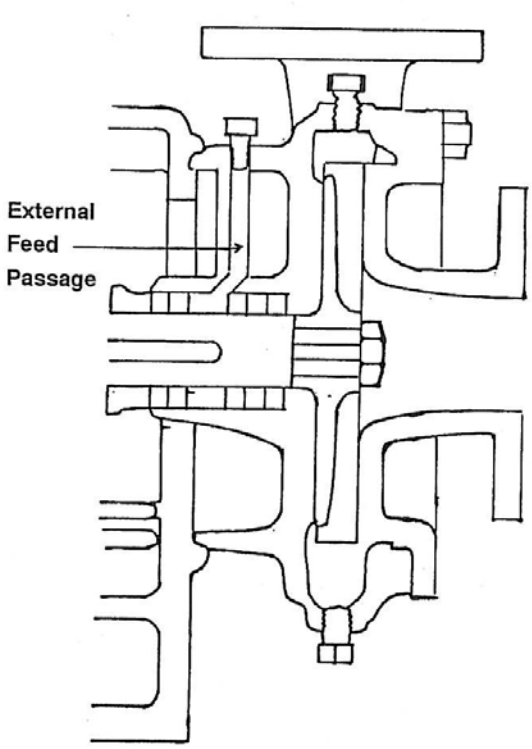
CLEANING

It is very important to ensure that all traces of dirt, debris and adhering residues be removed from all surfaces.

Any passages or balancing holes and lantern rings should be cleared, using a suitable prodding tool or drill.

Note usual location of balancing holes and passages on this diagram.





PUMP WITH EXTERNAL PACKING FEED

ASSEMBLING

The reassembly of an end suction pump is a relatively simple operation (which is one of the reasons for its popularity). The basic rules for reassembly are as follows:

- Work in **clean** conditions.
- Keep tools and hands clean to handle parts -especially the bearings.
- Make sure to remove all traces of old gasket or jointing material before matching any faces.
- Take time to 'dress down' any nicks, burrs or corroded surfaces, especially on joint faces.
- Apply anti-seize compound to fasteners and wear sleeves (into the shaft area).
- Lubricate, with oil, the outer surfaces of the shaft bearings which should be a 'slip-fit' into the bearing bracket.
  NOTE: Bearing installation procedures are covered in TECH AV programmes B.B.M. (Basic Bearing Maintenance).
- **Renew** all 'normal' wearing parts such as:
  > Bearings.
  > Oil seals.
  > Gaskets.
  > Wear sleeves.
  > Wear rings.
  > Packing rings.
- Following any special assembly procedures as per the detail of the manufacturers manuals or guides.

- Where applicable check impeller to wear ring clearances. (Procedures for this operation vary according to design -check the work manuals).
- Tighten the bearing bracket to volute casing fasteners in a progressive, diagonal sequence.
- Check that the shaft turns freely by hand. **If** any tightness or binding occurs check the following:
  > Uneven tightening of bracket fasteners.
  > Impeller clearance too small.
  > Bearings not seated correctly.
  > Shaft bent or eccentric condition exists.
- Unless the pump is to be put back into service immediately then it is recommended that soft-packings be left out. Packings are replaced *I* renewed at the time of pump installation. (See notes on packing).

TASK NO.3
SELF CHECK EXERCISE

INSTRUCTIONS

1) Following the demonstration on the video plus the recommendations in the resource notes. **Inspect, clean, and assemble** the pump previously dismantled.

Check against the self-evaluation criteria when you have completed the work.

TASK NO.3
SELF EVALUATION

Check the criteria below and indicate with a tick (√) in the YES or NO column.

ITEM	CRITERIA	YES	NO
INSPECTING	All parts inspected and wear/damage noted.	◯	◯
CLEANING	All surfaces cleaned.		
	Gasket/sealant particles removed.		
	Contact surfaces de-burred.		
	Passages balance holes, lantern cleared.	◯	◯
ASSEMBLING	Shaft and bearings carefully installed.		
	Oil used on bearing surfaces.		
	Bearing covers replaced with sealer.		
	Flinger replaced onto shaft.		
	Wear sleeve replaced with key (as applicable).		
	Anti-seize used on sleeve surfaces.		
	Impeller installed - nut and washer (as applicable).		
	Impeller nut tightened securely.		
	New gasket installed (bracket to case).		
	Bracket to case - fasteners evenly secured.		
	Shaft turns without binding.	◯	◯
	TOTAL		

HAVE YOUR INSTRUCTOR OR COURSE CONTROLLER CHECK YOUR WORK.

DATE: _____

COURSE CONTROLLER SIGN: _____

SINGLE STAGE PUMPS - BCP-2
CRITERION TEST

INSTRUCTIONS
PART(1) - THEORY
Answer the following questions.

	YES	NO
QUESTION 1: **What 'category' bearings must be fitted to a pump?** ANS:_____ _____	○	○
QUESTION 2: **Which openings, passages etc. must be cleared or cleaned during an overhaul?** ANS:_____ _____	○	○
QUESTION 3: **Which components should normally be replaced on an overhaul?** ANSWERS 1) _____ 2) _____ 3) _____ 4) _____	○	○

CRITERION TEST - PART 2
PRACTICAL EXERCISE

1) Ask you Instructor / Course Controller for a single-stage, end suction pump to work on.
2) Perform a full dismantling, inspecting and reassembling procedure on it.
   NOTE: You may refer to A MANUFACTURERS manual only (if available) during the practical exercise.
3) Ask your Instructor / Course Controller to check your work upon completion.

CRITERION TEST - BCP-2
EVALUATION - CHECK SHEET / REPORT

ITEM		CRITERIA	YES	NO
1)	**THEORY**	All questions answered correctly.	○	○
2)	**DISMANTLING**	All faces / critical surfaces cleaned up. All passages, drillings, balancers open.	○	○
3)	**ASSEMBLING**	Oil and/or anti-seize used on fitted parts. Impeller and sleeve fitted correctly. Gland assembly correctly fitted. Bracket to volute gasket installed. Pump turns freely by hand.	○	○
		TOTAL		

WORK CHECKED: _____

CAPACITY: _____

CRITERION OBTAINED

YES ☐	NO ☐

INTRODUCTION

This programme provides you with the necessary resource information to allow you to learn the correct procedures for dismantling -inspecting and assembling a typical SULZER multistage centrifugal pump.

The resource material consists of:

1) This **workbook** which contains step by step procedures to enable you to perform the work (BCP-3 and BCP-4).
2) Two **video** programmes, which demonstrate how to perform the necessary operations.
3) Your Instructor or Course Controller who will assist you and test your competency.

NOTE**:** Competency is evaluated from the assessment of both your knowledge and skill concerning the tasks outlined in this programme.

OPTIONAL RESOURCES

1) Sulzer wall charts available on request.
2) Sulzer HPL operating instruction manual.

HOW TO USE THIS PROGRAMME

Please read this page **carefully** before continuing.

INSTRUCTIONS FOR LEARNING

1) Read the overall objective on the next page. Then, if you consider that you can already perform the procedures outlined, ask your Course Controller to allow you to attempt the Criterion Test.

IF NOT, THEN:

2) Begin the programme at Task No.1.
   - o Read the task objective.
   - o Where applicable read the resource notes.
   - o View the video programme following any verbal or on-screen instructions.
   - o Complete any self-test exercises or practical work as per the task instructions.

NOTE: Your Course Controller or Instructor is always available to assist you. If you have problems or are not sure how to go about the job -**ASK.**

OVERALL PROGRAMME OBJECTIVE
BCP-3

Upon completion of this programme you will be able to:

- **Describe** the working principles and name the components of a SULZER HPL type centrifugal pump.
- **Dismantle** a pump.
- **Inspect** components and check wear or clearances.
- **Assemble** a pump.

CRITERIA

- To the standards set out by the pump manufacturer.
- According to the Criteria stated in the evaluation check lists.

CONDITIONS

- Given the relevant tools, material and equipment.
- Under the supervision of a competent person.
- In an industrial training environment.

TASKS

1) Naming / describing parts and functions.
2) Dismantling HPL type pump.
3) Inspecting of dismantled components.
4) Assembling HPL type pump.

TASK NO. 1
PUMP PARTS / FUNCTIONS

TASK OBJECTIVE

Upon completion of this section you will be able to:

- Identify and correctly name the various components / parts of a typical centrifugal (multistage) pump.

CRITERIA

As listed in the criterion test -Task 1.

CONDITIONS

- Given access to a SULZER HPL type pump or sectioned diagram (wall chart).
- In a training workshop.
- Under the guidance of an Instructor or Course Controller.

TEST

- To answer questions either in writing or verbally.

INSRUCTIONS

- Read the resource notes on the following pages.
- Do the tests (as required).
  NOTE: No video is required for this section.

TASK NO. 1 - RESOURCE NOTES
OVERVIEW OF MULTISTAGE PUMPS

PURPOSE
The purpose of a multistage pump is to supply liquid/fluid at increased pressure or head to a system (e.g. boiler feed water).

BASIC OPERATING PRINCIPLE
In simplistic terms a multistage pump can be likened to a series of single stage, end suction pumps one behind the other.

Fluid entering the pump (suction end) is energised by an impeller and directed toward the eye of a second impeller via a **diffuser** and **overflow** piece. The **diffuser** directs the liquid flow from the impeller into a cavity or **volute** from whence it is forced into the overflow piece. Specially shaped **vanes** in the overflow piece change the fluid directional flow and feed the liquid into the eye of the next impeller, or stage element. At each 'stage' fluid is re-energised until by the end of the process or final delivery stage it is delivered at a pressure or 'head potential' required by the operation.

PRIMARY PUMP COMPONENTS
We must be able to identify pump components so that it is possible to understand instructions in the workshop manual and for purposes of ordering or requesting spare parts.

NB: If available you may refer to SULZER WALL CHART FOR HPL-18-08 Pump (Drawing No. 1-1 04.601.143). For reference purposes we have included a pull-out copy of this chart on the following page.

You will notice that the example pump consists of 6 main elements:

- SUCTION CASING PART NO. 12.
- STAGE CASINGS PART NO. 11.
- DISCHARGE CASING PART NO. 13.
- A single shaft (PART NO. 31) carries 4 impellers (PART NO. 30).
- The shaft is supported on white metal bearings or 'plain bearings' (PART - NO. 42).
- Bearings are housed in 'bearing brackets'. One bracket (PART NO.40) is called the DRIVE END or D.E. bracket -notice that the shaft protrudes through this bracket. The opposite bracket (PART NO.41) is the Non-Drive End or ND.E. bracket. This bracket is closed at the end by the End Cover (PART NO.41.1).
- The shaft is sealed with soft 'gland packings' at both drive end (PART NO.51.11) and at the non-drive end (PART NO.5.11) stuffing boxes.
  The whole assembly, except the bearing brackets, is retained in alignment and secured by 'tie-bolts' placed around the outer peripheries (PART NO.11.1).

You have probably noticed by now that the 4th stage casing lacks an impeller and its associated diffuser and overflow piece. This stage is known as a 'Dummy stage' and is provided by the manufacturer (on request of client) for purposes of increasing the pump

capacity should the need arise. All the user has to do is fit the necessary components etc. to the stage and effectively increase the pumps rating.

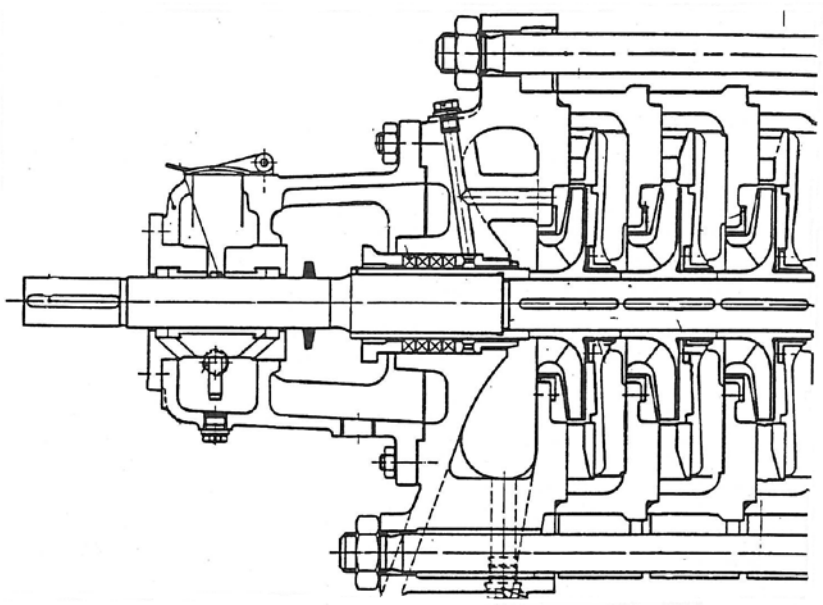
A CLOSER LOOK

More detailed inspection of a pump reveals the fact that several components feature that we have not yet mentioned.

Let's begin in the shaft area, where some very important features need mention. As already seen the shaft is sealed with packings (PARTS 51.11 AND 53.11). To avoid shaft scoring these packings run against 'sleeves' (PARTS 31.2 AND 31.24 respectively) which are designed to be replaced, should the need arise, without replacing the whole shaft. Note that the ND.E. sleeve (PART 53.11) is threaded onto the shaft and buts against (PART NO.32) a 'balancing disc'.

We shall discuss the balancing disc in some detail shortly, however lets continue with the other shaft features.

Look at the D.E. stuffing box area. You will notice (PART NO.51.4) called a 'neck bush'. Its main function is to provide a flow of liquid to the packIng rings via the lantern or labyrinth ring included.



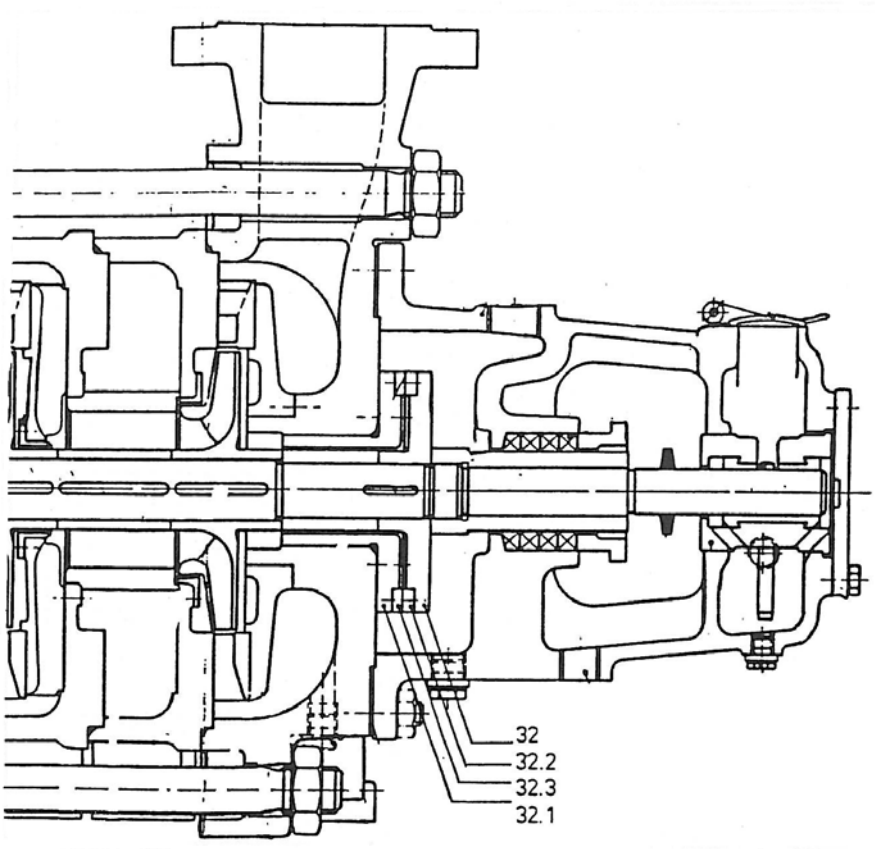
A clearance between shaft and neck bush allows fluid to flow to the soft packings thereby providing both lubrication and air exclusion. A drilled passage in the suction casing directs fluid flow to the lantern ring. The plug **(PART 12.14**) is provided so as to enable external water to be piped into the seal area under pressure. This feature is necessary when a pump is operating on SUCTION LIFT to ensure *positive* air exclusion.

Each impeller boss protrudes' into an *'overflow* piece' **(PART 21**). To maintain minimum clearance and therefore maximum pumping efficiency a 'small-wear-ring' **(PART 21.3**) is installed. Clearances are prescribed by the manufacturer and, by **replacing** the wear rings

periodically pumping efficiency may be restored.

Large wear rings **(PART 11.2**) *provide* the means of maintaining correct clearances between the large impeller boss and the casing(s) .

To *provide* a flow channel through the dummy casing a 'dummy bush' (**PART 21.17**) and 'dummy shaft bush' (**PART 31.28**) are installed.



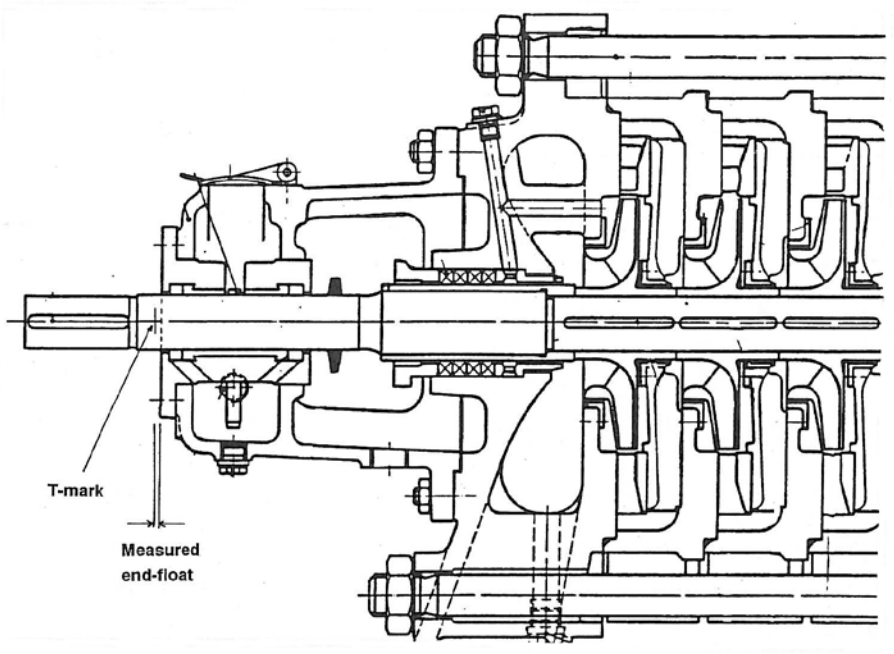
BALANCING COMPONENTS

We mentioned earlier that a balancing disc is installed and secured with the threaded shaft sleeve **(PART** 31.2). Observe enlarged section on diagram above.

The balancing components consist of parts 32 • 32.2 • 32.3 **and** 32.1.

Items 32.2 and 32.3 are the 'wear rings'. These rings are designed to provide the correct 'shaft float' .As the pump works the impellers tend to **thrust** in the direction of the Drive End, and without a counteracting device they would eventually drive themselves into the casings, with disastrous results. The balancing unit counteracts this effect.

However, it is necessary to **renew** the wear rings periodically when they have worn to prescribed limits. The limits can be measured by checking the shaft and float (using a dial-test-indicator) or by measuring the 'T' mark on the shaft at the drive end.



Many operators fit a 'limiting switch' to the N.D.E. of the shaft which is set to shut the pump down when the wear limit has been reached. This feature can save many thousands of rands in repair work and lost production.

Refer back to the main diagram. **PART NO. 31.26** known as a Throttling Bush' allows a determined flow of liquid to pass into the cavity in the N.D.E. bearing bracket thus surrounding the balancing unit. Fluid is drained off via the outlet NO.97.1 whence it flows back to the inlet or to a sump.

BEARINGS

A few notes concerning the bearings are necessary to conclude the parts / functions overview. In the illustrated example the bearings are of the plain type. 'White metal' coating protects the surface against which the steel shaft runs.

To ensure a long life an adequate supply of CLEAN oil must be provided continuously. An oil level 'sight glass' (**PART 40.11**) ensures that the oil can be seen at a glance and the correct level maintained.

In order to distribute the oil to each side of the bearing liner a 'lubricating oil ring' rotates freely on the shaft (**PART 42.15 and 43.15 N.D.E.**) picking up oil as it rotates and throwing it onto the liners. It is extremely important to ensure that both the correct amount of oil and the correct type is maintained. (S.A.E. 20 being recommended for South African conditions).

Situated between the stuffing box and the bearing housings at both D.E. and N.D.E. are 'flingers' (**PART 31.46 and 31.47**). These rotate as a fixture on the shaft and act to ensure that liquid leaking from the packing does not creep into the bearings.

TASK NO. 1 - PRACTICAL EXERCISE
PARTS AND FUNCTIONS

INSTRUCTIONS

Without reference to your notes answer the following:

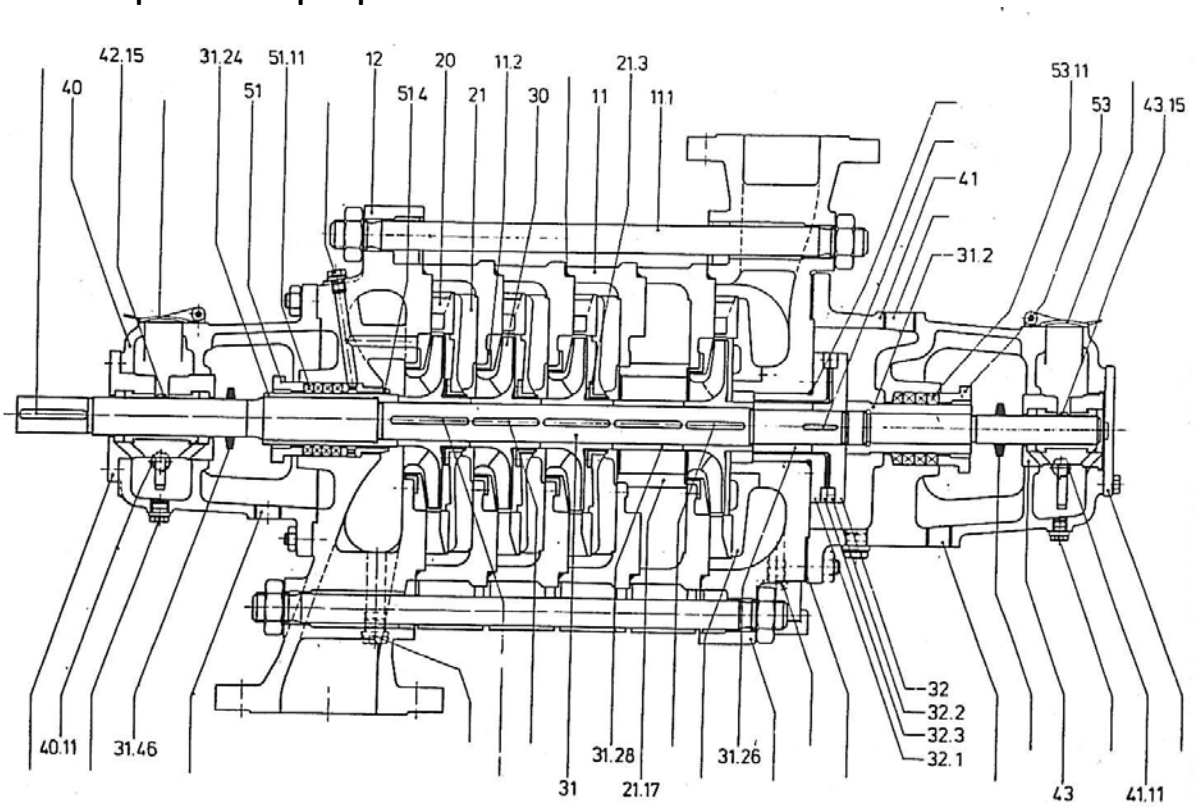
QUESTION 1:

Describe in your own words how a typical multistage pump operates.

ANS: _____

QUESTION 2:

Name the parts of the pump indicated below.



Write your answers on the following page.

WORK ASSESSED BY: _____

CRITERION OBTAINED: YES / NO ☐☐

DATE COMPLETED: _____

PART NAMES (LIST FOR QUESTION 2)

	YES	NO
TOP NUMBERS		
40		
41.25		
31.25		
51		
51.11		
12		
51.4		
20		
21		
11.2		
30		
11		
21.3		
11.1		
41		
31.2		
53.11		
53		
43.15	○	○
LOWER NUMBERS		
40.11		
31.46		
31		
31.28		
21.17		
31.26		
32		
32.2		
32.3		
32.1		
43		
41.11	○	○

TASK NO. 2
DISMANTLE PUMP

TASK OBJECTIVE
Upon completion of this section you will be able to dismantle a typical multistage SULZER pump.

CRITERIA
- As per the practical assessment.

CONDITIONS
- Given the necessary tools, equipment and materials.
- In a training environment.-Under the guidance of an Instructor/Course Controller.

TEST PRACTICAL
- To demonstrate the correct method and procedure for dismantling a pump.

INSTRUCTIONS
- Read the resource notes first.
- View the video **(BCP-3) Part One.**
- Attempt the practical work.

TASK NO. 2 - RESOURCE NOTES
DISMANTLE MULTISTAGE PUMP

PREPARATION

An area which is commonly overlooked is the attention to your work area BEFORE you attempt to pull a piece of equipment apart. The procedure to preparing your work area is as follows:

1) Clean the workbench.
2) Clean the work piece (i.e. the pump in this case).
3) Clean all tools.
4) Collect all necessary equipment.
   NOTE: We may sound fussy but be assured that cleanliness at the dismantling stage can really make your job easier at the assembly stage. A sloppy, dirty worker produces work that does not come up to standards expected.
5) Clean up the threads of any jacking screw holes with a suitable hand tap to remove paint, rust etc.
6) Ensure that all spanner sizes selected fit the fasteners properly (don't use stretched or worn tools).
7) Obtain a clean rubber mat on which to place removed components such as impellers, balance disc and other machined components -to protect them from damage.

DISMANTLING PROCEDURE

1) Ensure the pump is placed onto a flat and level working surface.
2) Use guide rails to facilitate sliding of stage units.
3) Clamp the suction case to the guide rails with suitable clamps.
4) Lift the ND.E. oil ring and rest it onto the bearing liner.
5) Slacken off the gland -remove packings.
6) Remove the bearing bracket -use jacking screws.
7) Remove threaded sleeve. Use a key bar with an assistant to secure shaft.
   NB : Avoid damaging the hexagon by ensuring that the spanner is of correct size.
8) Remove the balancing disc and throttling bush.
9) Remove plugs from jacking threads in the counter disc.
10) Remove counter disc, jacking screws used.
11) Remove all tie bolts.
12) Oil the guide rails.
13) Prise off the delivery case with suitable pry bar.
14) Slide case carefully off the shaft and store it.
15) Clean off any scale I corrosion in front of impeller.
16) Remove all exposed feather keys.
17) Slide off impeller.
    NB: If necessary heat around the **centre of the impeller** with a blow torch to release shaft bite.
    CAUTION: DO NOT OVERHEAT as this will damage or destroy impeller.
18) Remove feather keys.
19) Continue removal of all stages in the above mentioned manner (i.e. using pry bar

and sliding along guides).

20) Slacken D.E. packings (remove if necessary) .

21) Lift D.E. oil ring and rest on bearing liner.

22) Remove drive coupling (if attached) and key from shaft.

23) Remove D.E. bracket same procedure as ND.E. bracket.

24) Slide shaft out of suction case (complete with shaft sleeve and last stage impeller) .
NB: Heavy shafts should be stored in an UPRIGHT POSITION.

25) Stack all assemblies on a rubber or plastic mat to avoid damage.
CAUTION: DO NOT STACK PARTS ONTO CONCRETE FLOOR.

NOW VIEW VIDEO PROGRAMME NO.3
DO EXERCISE OVER PAGE WHEN VIDEO HAS BEEN VIEWED.

TASK NO. 2 - PRACTICAL EXERCISE
DISMANTLE MULTISTAGE PUMP

INSTRUCTIONS

1) Ask your instructor/course controller for a suitable multistage pump to work on in the training workshop.
2) Perform all necessary operations for fully dismantling the unit, observing any safety instructions/regulations.

ITEM	CRITERIA	YES	NO
PREPARATION	1) Work area clean.		
	2) Tools/equipment clean.		
	3) Correct tools selected.		
	4) Pump cleaned.	◯	◯
DISMANTLING	1) Pump clamped onto guide rails.		
	2) Oil rings lifted.		
	3) N.D.E. gland slackened/removed.		
	4) Bearing bracket jacked off.		
	5) Threaded sleeve loosened - correct spanner.		
	6) Counter disc jacked off.		
	7) Delivery case prised off carefully.		
	8) Corrosion cleaned off shaft.		
	9) All parts carefully removed.		
	10) Parts stored on rubber/plastic mat.	◯	◯

WORK ASSESSED BY: _____

CRITERION ATTAINED: YES / NO ☐☐

DATE COMPLETED: _____

LEARNER MAY PROCEED TO TASK NO.3 IF THIS TASK SUCCESSFULLY COMPLETED.

TASK NO. 3
PARTS INSPECTION

TASK OBJECTIVE
Upon completion of this section you will be able to perform a typical inspection of all pump components and assess critical wear factors.

CRITERIA
As per practical assessment.

CONDITIONS
- Given the necessary tools and equipment.
- On the pump previously dismantled in Task No.2.
- Under guidance of an Instructor/Course Controller.

TEST - PRACTICAL
- To demonstrate inspection/repair procedures.

INSTRUCTIONS
- Read the resource notes first.
- View the video **BCP-3 Part One.**
- Attempt the practical work.

TASK NO. 3 - RESOURCE NOTES
INSPECT PARTS / ASSESS WEAR

GENERAL NOTES

When the pump is completely dismantled we have the ideal opportunity to check for such things as, internal damage, impending damage and replacement of worn parts. Sometimes you will notice **obvious** problems, such as missing bolts, broken impellers etc.

Other items will need more detailed scrutiny and, often, measurements need to be taken to establish wear factors, run-outs etc.

It cannot be over emphasised that a very careful and detailed inspection of **ALL** the components is vital to ensure that faulty components are not reinstalled.

In this programme we shall detail each major component section one by one beginning with the:

SHAFT

Check the shaft carefully for the following:

> Scoring or wearing.
> Corrosion and pitting.
> Distortion -which must be performed using V-blocks, dial-test-indicator on surface table.

Any damage or distortion to the shaft will mean that either it must be repaired or renewed.

BEARINGS (LINERS)

Check the bearing liners for:

> Scoring or other damage.
> Wear movement, using D.T.I. (bearing on shaft) .

Don't replace worn or faulty liners -**renew** them.

WEAR SLEEVES (THREADED SLEEVE AND D.E. SLEEVES)

It is normal practice to renew the wear sleeves however should they be considered for re-use then check:

> For scoring or pitting.
> Condition of thread (for threaded sleeve).
> Condition of hexagon (for threaded sleeve).

NECK BUSH

Here a critical factor is the running clearance between the 'bush' and the wear sleeve. The most accurate method of establishing this is by actual micrometer

measurement. If the bush 1.0. clearance exceeds the nominal figure given in the work manual then renew the bush.

NB : Feeler gauges yield acceptable results.

Further inspect the bush for any damage.

Check that the 'lantern' section is not choked up with scale or debris. Clean out the passages carefully.

THROTTLING BUSH AND COUNTER DISC

As these components work in unison they should be checked together. Firstly a visual examination should not reveal any physical damage such as scoring, pitting, corrosion or tool marks.

The clearance between the bush and disc bore should be measured with suitable micrometers or bore gauges. Clearance must not exceed the nominal dimension as per work manual.

Examine the wear ring surface for physical damage.

Check thickness of wear ring with a vernier calliper.

BALANCING DISC

In the usual course of events wear rings would be renewed. However if end float (shaft) is well within tolerance then, providing they are in no way damaged -**check** the following carefully:

> The wear ring surface of the balancing disc. It should not be scored, distorted, cracked or corroded.
> Check the wear ring thickness with a vernier calliper.

Remember always discard a damaged balancing disc and fit new.

END CASINGS AND STAGE CASINGS

The principal inspection on all casings is to check for such problems as:

> Cracks and abuse damage.
> Facing surfaces must be clean, free of corrosion and pitting.
> Flanges should be likewise, clean, not pitted and flat.
> Diffuser mounting bolt hole (threaded holes) must be carefully inspected and it is recommended that a suitable hand tap be used to 'chase' up the threads.
> Ensure pedestal brackets (feet) are flat and free of high spots.
> On the Suction Case check that the water passages are clean and open (to the lantern ring area) .
> On both End Casings check the condition of the studs which secure the bearing brackets. Replace any studs that are damaged, bent, or missing.

IMPELLER WEAR RINGS

The large wear rings are situated in casings and secured with specially counter sunk set screws. The **small** wear rings are situated in the overflow pieces and also secured with counter sunk set screws.

If the wear ring show signs of wear, scoring, pitting or corroding etc. they must be renewed with recommended replacement parts.

The radial clearances should be established between each wear ring and its corresponding impeller, using feeler gauges.

Renew wear rings when nominal clearances are exceeded to avoid severe head loss.

DIFFUSERS AND OVERFLOW PIECES

It is always recommended that both diffusers and overflow pieces by removed from their mountings for proper inspection -check the following:

> Damage to the vanes, either by erosion or from the intrusion of solid objects (e.g. a set screw or stone).
> Check for corrosion, erosion and distortion of the facing surfaces. Clean up threaded holes with a suitable hand tap.
NB : It is recommended that new set screws be obtained for reassembly purposes.
> Check that wear sleeve bores are clean, erosion and corrosion free and that the wear sleeves fit neatly into the bores.

IMPELLERS

Careful inspection of the impellers is vital. Key points are:

> The general condition (i.e. wear, erosion and balance devices).
> Boss surface condition and wear (i.e. wear ring area).
> Key slot condition.

Replace (renew) any impeller that is damaged, ensuring that the **correct** replacement is selected.

Clear out any blockage between the outer face plates and vane passages.

Clean out any restriction in balance holes (where applicable).

Check the impeller to shaft fit and key slot movement. Renew worn feather keys.

STUFFING BOXES

Ensure that the inner stuffing box bores are not corroded or badly eroded.

Check the gland studs for damage or thread problems. Renew damaged studs.

Check gland (flanges) for straightness, bore condition and fit into the stuffing box bore. A slip fit is essential.

BEARING BRACKETS

As with casings, check for cracks, distortion and abuse damage.

Ensure drain plugs are secure.

Clean out all dirt and debris from oil gallery.

Check condition of oil rings.

Check bearing end cover (ND.E.) for flatness.

Check D.E. bearing liner unit for fit into housing and ensure oil ways are clean and clear.

TIE BOLTS

Last but not least check the tie bolts. They have to work hard so don't under estimate their importance. Clean up the threads with a wire brush and if necessary run a die nut over the threads. Don't overlook the nuts either -renewal of nuts is good practice.

NOW CONTINUE LEARNING BY WATCHING THE VIDEO. PROCEED TO DO TASK NO.3 PRACTICAL AFTER WATCHING VIDEO SECTION (INSPECTION)
TURN PAGE TO CONTINUE

TASK NO. 3 - PRACTICAL EXERCISE
INSPECTION

INSTRUCTIONS

1) Perform a full inspection and repair of components on the pump previously dismantled.
2) Make out a full condition report on every component inspected.

ITEM	CONDITION
BALANCING DISC	CRACKED - NOT USABLE
THROTTLING BUSH	GOOD - WITHIN SPEC.

3) You will find a blank condition report sheet on the next page. If you require extra room ask your Instructor / Course Controller to make you a photocopy from his master sheet.
4) Please refer to the **manufacturers spec plate** on the pump for details such as pump type and model.

REPORT SHEET
MULTISTAGE PUMP

PUMP TYPE: _____ MODEL: _____

INSPECTED BY: _____ DATE: _____

ITEM	CONDITION

ASSESSMENT
PUMP PARTS INSPECTION

ITEM	CONDITION	YES	NO
SHAFT		○	○
BEARING UNITS		○	○
WEAR SLEEVES		○	○
NECK BUSH		○	○
THROTTLING BUSH/ COUNTER DISC		○	○
BALANCING DISC & WEAR RINGS		○	○
END & STAGE CASINGS		○	○

ITEM	CONDITION	YES	NO
IMPELLER WEAR RINGS		○	○
DIFFUSERS & OVERFLOW PIECES		○	○
IMPELLER		○	○
STUFFING BOXES		○	○
BEARING BRACKETS		○	○
TIE BOLTS		○	○

WORK ASSESSED BY: _____

CRITERION OBTAINED: YES / NO ☐☐

DATE COMPLETED: _____

LEARNER TO CONTINUE ONTO TASK NO.4 IF TASK NO.3 SUCCESSFULLY COMPLETED.

TASK NO. 4
ASSEMBLING

TASK OBJECTIVE
Upon completion of this section you will be able to perform a typical assembling procedure on the pump previously inspected.

CRITERIA
As per practical assessment.

CONDITIONS
- Given all necessary tools / equipment.
- On the pump previously worked on (Task No,3).
- Under the guidance of an Instructor / Course Controller.

INSTRUCTIONS
- Read the Resource notes.
- View the video **BCP-3 Part** Two.
- Attempt the practical work.

TASK NO. 4 - RESOURCE NOTES
PUMP RE-ASSEMBLY

GENERAL NOTES

When reassembling the pump it is important to ensure that all gaskets and *'0'* rings are **renewed.**

DO NOT USE OLD GASKETS etc.

Coat all interference fitting components with an anti-seize compound such as Copper coat or Nickel-plate.

DO NOT USE **GREASE.**

Only use **plastic or rubber** mallets for tapping in parts.

Trial' assemble all impellers, throttling bush, balance disc and threaded shaft sleeve onto the shaft. Check the run out at the mid-point using a D.T.I. (shaft supported on suitable V-blocks).

Leave D.E. shaft sleeve on the shaft -remove all other parts now for assembly.

As with dismantling ensure that your work area is spotlessly **clean.**

Set guide rails onto the flat topped workbench. (NOTE: A steel surface is ideal -it should be perfectly flat to ensure correct alignment of components.)

Use your diagram or workshop manual to assist in parts replacement.

A) SUB UNIT ASSEMBLIES

The assembly procedure begins by putting each case and stage unit together.

1) SUCTION END CASING

- Fit and secure large wear ring. Tighten up the set screws evenly and firmly.
- Install the Neck Bush by tapping it in with a suitable dolly (soft material such as copper or vesconite) .
- Set casing up onto assembly, raise and clamp securely.
- Fix gland follower and its fasteners (loosely).

2) STAGE CASINGS

- Insert and secure large wear rings, tightening screws evenly.
- Position the overflow piece into casing (opposite side).
  NB: Be sure to properly locate the spigot.
- Fit and tighten the 4 set screws.

- Fit and tighten the small wear ring into overflow piece.
- Position the diffuser against the overflow piece. (Notice that no screws are used here).
- Assemble each stage similarly and set aside ready for final assembling.

3) DISCHARGE CASING

- Apply anti-seize coating to hub of counter disc.
- Fit new '0' ring.
- Press counter disc into casing bore (plastic hammer).
- Align to holes and fit screws. Tighten securely.
- Insert the last diffuser plate and the diffuser. Note that no screws are used (see sectioned diagram and note how the diffuser and plate are secured by compression of the stage housing behind the discharge casing) .

4) BEARING BRACKETS

- Apply oil to support surfaces (i.e. bores) .
- Slip liners into brackets.
- Insert oil ring over liners as you insert them.
- Tap liner into position.
  NB: Align the locating ball on ND.E. liner to recess (notch) in bracket bore.
- Fit and secure cap screws to D.E. flange cover.
- Fit ND.E. cover if a limit switch is not going to be fitted.
- Fit gland follower to ND.E. bracket.

B) FINAL ASSEMBLY

The prepared sub units are now assembled together.

- Fit the D.E. bracket (install) to the suction case.
- Secure the fasteners firmly and evenly to ensure bracket sits squarely against mating surface.
- Lift oil ring and lay it onto the liner.
- Fit throttling bush and first stage impeller keys to the shaft (Note longer keys used at first stage) .
- Install the shaft (carefully) into the suction case.
- Have an assistant fit the 'flinger', and guide the shaft into the bearing liner.
- Fit a new '0' ring to the suction case.
- Oil the shaft.
- Fit first impeller (spray *I* apply anti-sieze to wear faces) and engage it onto feather keys.
- Fit next set of feather keys.
- Slide on the first stage case.
- Fit impeller and keys.
- Fit next case '0' ring.
- Slide next case into position.
- Repeat procedure for successive stages.
  NB: If dummy stage is fitted this will always be situated behind the delivery stage.

- Fit (if equipped) dummy stage parts:
  - > the hydraulic sleeve
  - > the dummy bush to shaft.
- Fit final case '0' ring.
- Fit the last impeller (onto shaft).
- Fit new '0' ring to the counter disc.
- Apply anti-seize to the sleeve area.
- Fit and secure counter disc into delivery casing.
- Slide delivery casing into final position.
- Fit and secure (evenly) all the 'tie' bolts.
  NOTE: REPLACE THE TWO THREADED PLUGS INTO THE COUNTER DISC. FAILURE TO DO THIS WILL RESULT IN SERIOUS PROBLEMS IN THE BALANCING UNIT.
- Check that the pump shaft is aligned with delivery casing by:
  - > Testing with feeler gauge between the throttling bush (now installed) and the counter disc. The gap (see specification) must be even / uniform all around the periphery.
  - > Tighten relevant tie bolts to make small alignment adjustments.
- Fit the feather key for balancing disc.
- Fit balancing disc.
- Fit and tighten the threaded sleeve. (An assistant secures the shaft with keyed lever.)
- Push shaft toward the drive end (i.e. the balancing unit is 'closed').
- Check if any gap exists between the balancing unit wear rings. Test all round the unit with your smallest (i.e. thinnest) feeler gauge. **NO GAP MUST EXIST**.
- Check the axial movement on the shaft (thrust shaft toward the non drive end).
- **Measure movement by**:
  - > i) Feeler gauges between balance unit wear rings.

  OR
  - > ii) Measuring distance with a D.T.I. (dial test indicator).

  NB: If movement exceeds limits -new wear rings should be installed.
- Fit new gasket to ND.E. bracket mating surface on delivery case.
- Fit ND.E. bracket -observing same procedure as or the D.E. bracket.
- Check pump rotation -it should turn by hand.
  NOTE: If pump is to be installed immediately then top up the bearing oil galleries with specified oil -to the sight level mark.

Fit soft packings to glands (see procedure as in workbook No.1)

TASK NO. 4 - PRACTICAL EXERCISE
ASSEMBLE MULTISTAGE PUMP

INSTRUCTIONS

1) Assemble the pump, previously dismantled in Task No.2, as per the procedures and methods demonstrated.

ITEM	CRITERIA	YES	NO
PREPARATION	Work area properly cleaned.		
	New gaskets, 'o' rings, seals collected.		
	Shaft assembled with impeller/sleeves, balance unit and threaded sleeve.		
	Run out checked at centre.		
	Shaft correctly supported on V-blocks.		
	Components correctly handled to avoid damage.	○	○
SUB ASSEMBLING	Suction end casing correctly assembled.		
	No damage caused by tool etc.		
	All stage casings correctly assembled.		
	Matching components fitted to above.		
	Discharge casing correctly assembled.		
	Anti-seize compound used on fitted parts.		
	'O' rings fitted as necessary.		
	Bearing brackets correctly assembled.	○	○

EVALUATE YOUR WORK AGAINST THE CHECKLIST BELOW

ACTIVITY/ITEM	CRITERIA	YES	NO
FINAL ASSEMBLY	Suction casing clamped onto guides.		
	D.E. brackets fitted with gland follower.		
	Shaft with sleeve fitted.		
	Flinger fitted.		
	Case 'O' rings fitted.		
	All keys positioned.		
	Impellers correctly fitted.		
	Casings (stages) correctly positioned.		
	Counter disc 'O' ring fitted.		
	Counter disc plugs fitted.		
	Counter disc correctly installed.		
	Delivery stage correctly positioned.		
	Tie bolts fitted and evenly tightened.		
	Throttling bush and key fitted.		
	Alignment checked (at throttling bush).		
	Balancing disc fitted.		
	Threaded sleeve fitted and secured.		
	Wear rings checked for zero gap.		
	Axial movement checked.		
	N.D.E. bracket and gasket fitted.		
	N.D.E. bracket properly secured.		
	Cover fitted (N.D.E.) if no limit switch required.	○	○

WORK CHECKED BY:_____

DATE: _____

CRITERION / COMPETENCY TEST

INSTRUCTIONS

NB: This test is to be conducted without reference to your notes or other resource material.

1) Dismantle, inspect and re-assemble a multistage centrifugal pump in your training workshop.
2) Make out a condition report on the pumps components. You will be assessed by the following criteria / standards:
   - Adherence to procedures demonstrated in programme.
   - Knowledge of components part names.
   - Selection of tools / equipment.
   - Safe working methods.

REPORT SHEET
MULTISTAGE PUMP

PUMP TYPE: _____ MODEL: _____
INSPECTED BY: _____ DATE: _____

ITEM	CONDITION