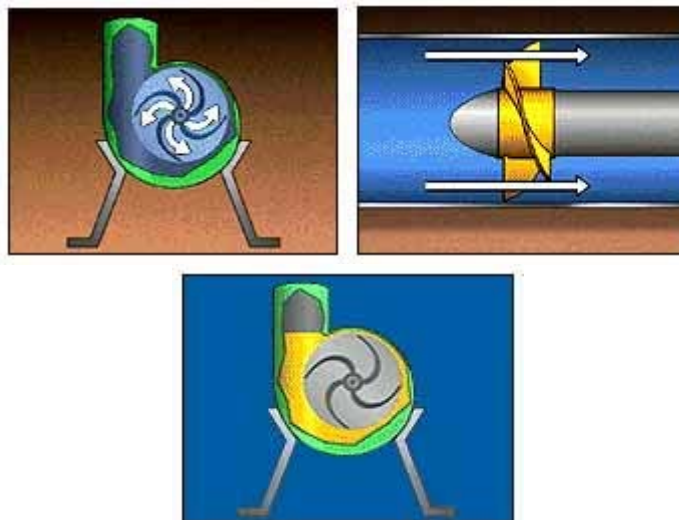


CENTRIFUGAL PUMP BASICS AND TROUBLESHOOTING



STUDY GUIDE

NOTE

THIS DOCUMENT CONTAINS PRACTICE ACTIVITIES SIMILAR TO THOSE THAT YOU WILL SEE DURING THE PERFORMANCE EVALUATION. THE EVALUATION INSTRUCTIONS WILL BE AN ABBREVIATED VERSION OF THIS STUDY GUIDE.

NUMBER: 19-2	ACTIVITY: Identify a selected centrifugal pump and explain its components. Conduct operational checks and inspections for possible troubleshooting.
ESTIMATED TIME: 2.5 hrs.	
NOTE <i>In this activity, trainees will be given selected types of centrifugal pumps. Trainees will be asked to identify various types and their main components. Also, they will be asked to perform operational checks and inspections for possible troubleshooting of centrifugal pumps.</i>	
<u>SAFETY</u> <i>Safety glasses with side shields will be worn at all times. Trainees will comply with company guidelines for clothing and additional personal protective equipment (PPE) that must be worn during the performance evaluation. Additional, task-specific, PPE items such as full-face shields will be available to the trainees, and will be worn by the trainees, when the activities create possible risks or hazards. Those hazards and the PPE items associated with them will be identified in the written instructions.</i>	

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OBJ. #	<u>OBJECTIVES</u>
AMPC1-1	Select a specific type of centrifugal pump from a collection of pumps, name it; and explain its main components, with 100% accuracy in the use of step-by-step written procedures.
AMPC1-2	Perform operational checks and inspections to troubleshoot centrifugal pumps with 100% accuracy in the use of step-by-step written procedures.

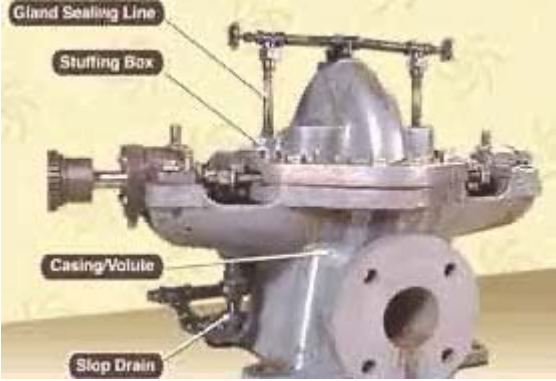
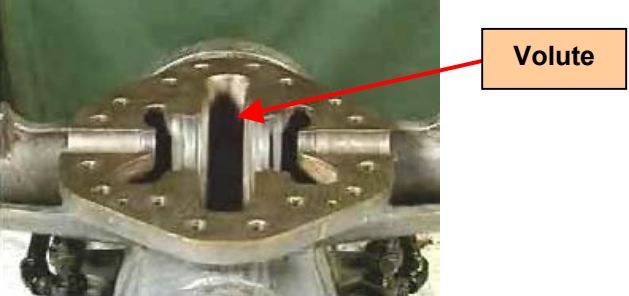
On the following pages are written instructions designed to help you demonstrate that you can properly identify a selected centrifugal pump and explain its main components; perform operational checks and inspections for possible troubleshooting. These instructions are based on the performance objectives listed above.

Each individual must perform the stated activity alone when being evaluated.

WRITTEN INSTRUCTIONS
FOR
CENTRIFUGAL PUMP BASICS AND TROUBLESHOOTING

INSTRUCTIONS TO TRAINEE

To successfully complete or pass this activity, you must correctly accomplish all steps, with no assistance or intervention from the evaluators, except for safety concerns. Evaluators will rate you as Pass or Fail on each of the following steps

STEP #	STEP ACTIVITY DESCRIPTION
1	Ensure that you are wearing all the personal protective equipment (PPE) required for the environment in which you are working at this time.
2	Identify the different designs of centrifugal pumps and explain the function of the main components. 2.1 A double suction closed impeller centrifugal pump normally has the intake and discharge on the same horizontal plane, and these are located below the centerline of the pump's shaft on either side of the pump casing. Almost all pumps of this design has horizontal split casings. Figure 2.1 shows a double suction, closed impeller centrifugal pump. 
	2.2 A double suction centrifugal pump's casing is cast with the suction inlet split into two separate flow paths to divert the fluid flow toward the inlets on each side of the enclosed casing impeller. The pressurized fluid discharge from the impeller is diverted toward the volute via the outlet port that is also cast into the casing of the pump. This discharge outlet is separated from the inlet ports on the suction side of the pump. Figure 2.2 shows the inside of a casing of a centrifugal pump. 

STEP #	STEP ACTIVITY DESCRIPTION
2	2.3 All pumps have drip pans cast into the pump casings under the stuffing box or mechanical seal areas to collect and divert leakage from the seals to either a floor drain or, in the case of toxic or radiated fluid leakage, to a holding tank. To prevent fluid spilling onto the floor and creating a hazard, the spillage is piped away from the pump area to a suitable disposal point. Figure 2.3 shows drip pan drain.  Drip Pan or Slop Drain
	2.4 Figure 2.4 shows the main components of a centrifugal pump that is not normally seen during operation of the pump. However, these components all play a major role in the efficient function of the pump in the following way: Figure 2.4 shows the internal parts of a centrifugal pump.  2.4.1 The impeller is a bladed member of the rotating assembly of the pump that imparts the principal force to the liquid being pumped.

STEP #	STEP ACTIVITY DESCRIPTION
2	2.4.2 The casing wearing ring, or rings, is a sacrificial wear down device that plays a double role in the pump's operation. The wearing ring acts as a seal between the high-pressure discharge side of the pump and its low-pressure side. It also acts as prevention against the casing being damaged by excessive shaft wear down.
	2.4.3 The packing gland assembly is designed to provide a barrier between the pumped fluid and the atmosphere. Packing rings are wrapped around the shaft and inserted in the cavity provided in the pump body. A gland follower compresses these packing rings until a slight trickle of fluid is allowed to leak from the gland for lubrication and cooling purposes of the packing rings.
	2.4.4 A lantern ring is often installed in the mid-section of the packing gland, or mechanical seal, to permit clean pressurized fluid to seal and lubricate the packing in the gland, or seal faces of a mechanical seal. If the fluid being pumped is considered "clean", this fluid is piped to the lantern ring orifice in the pump casing above the mid-point of the stuffing box for cooling and lubrication of the packing. The lantern ring can also act as a collection point for toxic or radiated fluid leaking past the inside rings of packing, or mechanical seal, before piping it off to a safe collection point.
	2.4.5 A slinger (sometimes called a flinger) ring is fitted onto the shaft between the bland stuffing box and the bearing to deflect gland leakage away from the bearing.
	2.4.6 The throat brushing, or shaft sleeve, is a cylindrical piece fitted over the shaft to protect the shaft through the stuffing box and which may also serve to locate the impeller on the shaft.
	2.4.7 A single suction impeller employs one low-pressure opening compared to two on a double suction impeller.
	2.4.8 A double suction closed impeller has two low pressure inlets and its vanes are contained by side shrouds which collect and direct the fluid toward the exit tips of the vanes and into the volute section of the pump.
	2.4.9 An open impeller has partial shrouds, which are relatively small by comparison to a semi-open impeller.

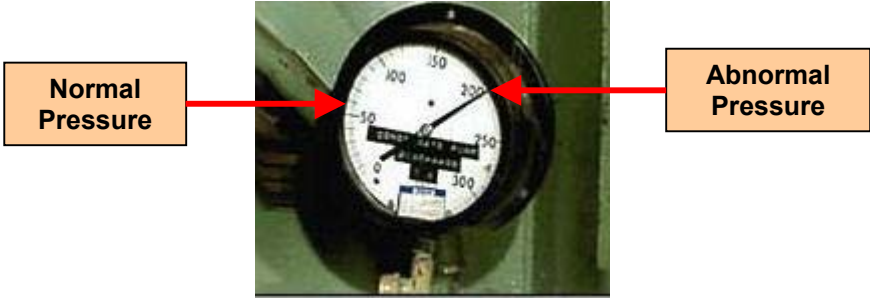
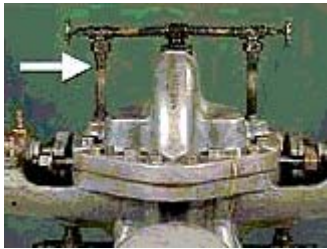
STEP #	STEP ACTIVITY DESCRIPTION
2	2.4.10 A semi-open impeller has a full diametrical or full circle back shroud onto which the open-faced vanes are cast. Figure 2.5 shows a single suction impeller.  SINGLE SUCTION IMPELLER Figure 2.6 shows a double suction closed impeller.  DOUBLE SUCTION IMPELLER Figure 2.7 shows an open impeller  Figure 2.8 shows a semi-open impeller  SEMI-OPEN IMPELLER
3	Perform operational checks and inspection of centrifugal pumps. Figure 3 shows an operator performing operational checks on a centrifugal pump. 

STEP #	STEP ACTIVITY DESCRIPTION
3	3.1 Talk to the pump operator first when you detect that something is wrong with the pump. The pump operator is familiar with the operating characteristics. Figure 3.1 shows a mechanic talking to the pump operator about the pump. 
	3.2 Ask the operator the following questions:
	3.2.1 What is the symptom?
	3.2.2 When did the symptom first appear?
	3.2.3 Did the symptom occur suddenly or gradually?
	3.2.4 What actions were taken to correct the symptom?
	3.2.5 Have there been changes in the operating characteristics of the pump? NOTE <i>A complete failure of a part is indicated when the symptom occurred suddenly. Normal wear and tear of parts causes the symptom to appear sporadically and gradually.</i>
	3.3 Identify the steps taken by the operator to solve the problem. Check to see whether these steps changed any of the operating characteristics of the pump.
	3.4 Verify that auxiliary components in the system are working properly before focusing attention on the pump.

STEP #	STEP ACTIVITY DESCRIPTION
3	3.5 Assemble the instruments, equipment, manufacturer's manual, operating logbook, and other information about the pump that might be helpful before inspecting the pump. <i>NOTE</i> <i>The specific items needed for troubleshooting vary depending on the pump and plant procedure.</i>
	3.6 Wear all of the personal protective equipment required by your plant's safety procedures such as; eye protection, hardhat, etc. Figure 3.6 shows the operator wear a hardhat and eye protection. 
	3.7 Perform routine inspections of the pump while it is operating to determine if anything unusual is happening which may indicate impending problems. Pay particular attention to increased smells, vibrations and temperature.
	3.8 Periodically check and record the electrical amperage of the motor during operation as increased amperage is a good indication of additional loading due to frictional build up due to shaft misalignment or poor lubrication. This must be reported immediately to supervision.

STEP #	STEP ACTIVITY DESCRIPTION
3	3.9 Investigate any noise or vibration by holding sounding devices such as a mechanic's stethoscope, a screwdriver, or piece of piping against your ear. Depending on the intensity of the symptoms, get a more professional analysis of the situation by using a vibration analyzer, an infrared camera, or an ultrasonic detector. Figure 3.9 shows a mechanic using a stethoscope 
	3.9.1 A loud rattling or clanging noise implies that some parts are broken or other objects are loose inside the casing. A growling or squealing sound indicates worn or damaged bearings.
	3.10 Investigate any loud rattling sounds from the pump casing that resemble the sound of marbles rolling around in a tin can. This is the telltale symptom of cavitation or recirculation within the pump casing. Cavitation takes place in the suction, or low-pressure side, whereas recirculation takes place in the discharge side of the pump. Cavitation takes place when the fluid entering the pump is at a higher temperature than its saturation pressure or, when the pressure head is lower than it should be to prevent flash-off taking place. A restricted suction flow is also responsible for cavitation. Recirculation on the other hand is created on the discharge side of the pump when a discharge valve is used for throttling or some other restriction prevents full flow of the fluid. The resulting backpressure energy is converted into heat energy and flash-off occurs.

STEP #	STEP ACTIVITY DESCRIPTION
3	Figure 3.10 shows cavitation.  NOTE <i>Cavitation can occur if the suction valve is not open all the way or if the suction port is blocked, resulting in further reduction of pressure at the suction eye. Low net positive suction head is also a contributing factor to cavitation.</i>
	3.11 Shut down the pump if necessary if cavitational or recirculation noises are loud and consistent and report the matter.
	3.12 Listen for other sounds of cavitation that include rapid fluctuation in suction pressure and overheating of the pump casing. This condition must be reported to the supervisor <u>immediately</u>.
	3.13 Look for abnormal readings. Figure 3.13.1 shows low reading on a discharge pressure gauge.  Figure 3.13.2 shows an abnormal reading in suction pressure gauge.  NOTE <i>When there is an abnormal reading, make sure that the gauge is functioning properly before assuming the problem is in the pump rather than in the gauge.</i>

STEP #	STEP ACTIVITY DESCRIPTION
3	3.14 Look for abnormal pressure gauge readings in pumps that have forced lubrication systems installed. Figure 3.14 shows an abnormal readings on a gauge 
	3.15 Severe leak off is another symptom of abnormal operation.
	3.16 Tighten the gland follower to minimize leak off. If that doesn't solve the problem, then look at the packing. Figure 3.16 shows too much leakage. 
	3.17 Verify that the casing flange bolts are properly torqued. Torque these bolts to the specified torque requirements, or replace the flange gasket completely to prevent leakage if the bolts are not torqued. Figure 3.17.1 shows too little leak off. Figure 3.17.2 shows a gland sealing line.  

STEP #	STEP ACTIVITY DESCRIPTION
3	CAUTION <i>If the casing bolts are being tightened down after an overhaul they should be incrementally tightened before being finally torque tightened to the finished specification. Each individual bolt must be slackened off before retightening it to the required torque value when the casing bolts are just being checked for tightness using a torque wrench. When the torque wrench is placed on the bolt and tightened until the torque wrench clicks, the operator has just over torqued the bolt by 20% thus increasing the stress on that bolt. After this routine has been applied as a standard, the bolt will eventually reach a point where it will shear.</i> 3.18 Look for leakage around the casing flange. Figure 3.18 shows leakage around the casing.  3.19 Verify that the flange bolts are properly torqued. If not, torque the casing bolts to the specified torque requirements, or replace the flange gasket to prevent leakage. 3.20 Check for lubricant leakage if the bearing housing is cracked.

STEP #	STEP ACTIVITY DESCRIPTION
3	3.21 Place the back of your hand on the pump casing to detect temperature. Figure 3.21 shows a mechanic using his hand to detect temperature.  WARNING <i>The pump could be very hot or very cold.</i>
	3.22 Whenever possible use a vibration meter to check excessive vibration, caused by misalignment of the shaft and coupling, bent shaft, damaged bearings, or worn out rings. The sound that accompanies the vibration should indicate the type of problem. Figure 3.22 shows a vibration meter used by an operator or mechanic. 

STEP #	STEP ACTIVITY DESCRIPTION
3	3.23 Use a pyrometer to check for overheating. Figure 3.23 shows a contact Pyrometer.  NOTE <i>Typical points for overheating are the bearings and stuffing box. Excessive heat in either of these locations usually indicates a problem with lubrication.</i>
	3.24 Check the manufacturer's manual for the temperature range specified for overheating on a particular pump.
	3.25 Shut down the pump if the problem cannot be rectified while the pump is still operating.
	3.26 Check for overheating by placing the back of the hand on a stuffing box or the bearing housing, but do so with great caution to avoid a painful burn! NOTE <i>It is important to realize that temperature precedes vibration.</i>
	3.27 Shut down and disassemble the pump in case of some internal problems. Figure 3.27 shows a mechanic shutting down the pump. 

STEP #	STEP ACTIVITY DESCRIPTION
3	3.28 Follow the electrical and mechanical lockout and tagout procedures to ensure safety. Figure 3.28 shows a mechanic's lockout and tagout for the pump that is to be serviced. 
	3.29 Open the pump casing to gain access to the internal parts of the pump to look for the possible cause of the trouble.
	3.30 Look for cavitation erosion in the impellers eye section. Figure 3.30 shows cavitation erosion in the impellers eye section. 
	3.31 Look for damage to the lantern rings. If the rings are worn or damaged, replace them to restore pumps efficiency. Figure 3.31 shows a mechanic inspecting the lantern rings. 

STEP #	STEP ACTIVITY DESCRIPTION
3	3.32 Look at the lantern rings and the gland sealing line to see if they are clogged. Clean the clogged parts if necessary.
	3.33 Look for worn or damaged packing rings if there is excessive leakage out of the packing gland. Replace the damaged or worn out packing rings. Figure 3.33 shows a damaged packing ring. 
	3.34 Damage to the sacrificial sleeve on the shaft would note ridges or grooves that have been cut into it by inadequate lubrication, or badly installed packing material, which has become scorched by excessive heat from friction. Figure 3.34 shows a damaged sleeve. 
	3.35 Determine the cause of the damage and rectify it before installing the repaired or new shaft. If the sacrificial sleeve is worn and grooved, it should be replaced.

STEP #	STEP ACTIVITY DESCRIPTION
3	3.36 Rotate the shaft to look for bearing problems. A bad bearing or a bent shaft can cause excessive drag.
	Figure 3.36 shows a mechanic looking for bearing problems. 
	3.37 Remove the bearings from the housing and inspect them if the bearing problem cannot be detected. Replace any damaged bearings.
	3.38 Check for impeller problems including clogs of solid material in the pumped fluid, incorrect mounting, or no rotation because the impeller has worked its way loose from the shaft.
	Figure 3.38 shows a mechanic looking for impeller problem. 
	3.39 Check for damage at the edge of the impeller vanes due to cavitation.
	3.40 Check the impeller for wear where the impeller comes in contact with the wear rings. Figure 3.40 shows a worn impeller. 

STEP #	STEP ACTIVITY DESCRIPTION
3	3.41 Inspect the casing and look for broken parts or severe pitting when the pump is making a loud rattling noise during operation. Figure 3.41 shows a mechanic looking for broken parts.  NOTE <i>The physical damage and pitting that takes place is identical in both cases, but, cavitation damage occurs in the suction eye of the impeller and recirculation damage occurs around the exit tips of the impeller's vanes.</i> 3.42 Remove all foreign objects or broken parts from the pump as soon as possible. Figure 3.42 shows a mechanic preparing to remove foreign objects. 
4	The assembled pump must now be installed in its operational position with all of the connections made and prepared for start-up.

When you have completed working through this Study Guide, return it to your Workforce Administrator.