Industrial Maintenance

Stuffing-Box Centrifugal Pump

Courseware Sample

37904-F0
The purchaser shall receive a single right of use which is non-exclusive, non-time-limited and limited geographically to use at the purchaser's site/location as follows.

The purchaser shall be entitled to use the work to train his/her staff at the purchaser’s site/location and shall also be entitled to use parts of the copyright material as the basis for the production of his/her own training documentation for the training of his/her staff at the purchaser's site/location with acknowledgement of source and to make copies for this purpose. In the case of schools/technical colleges, training centers, and universities, the right of use shall also include use by school and college students and trainees at the purchaser's site/location for teaching purposes.

The right of use shall in all cases exclude the right to publish the copyright material or to make this available for use on intranet, Internet and LMS platforms and databases such as Moodle, which allow access by a wide variety of users, including those outside of the purchaser's site/location.

Entitlement to other rights relating to reproductions, copies, adaptations, translations, microfilming and transfer to and storage and processing in electronic systems, no matter whether in whole or in part, shall require the prior consent of Festo Didactic.

Information in this document is subject to change without notice and does not represent a commitment on the part of Festo Didactic. The Festo materials described in this document are furnished under a license agreement or a nondisclosure agreement.

Festo Didactic recognizes product names as trademarks or registered trademarks of their respective holders.

All other trademarks are the property of their respective owners. Other trademarks and trade names may be used in this document to refer to either the entity claiming the marks and names or their products. Festo Didactic disclaims any proprietary interest in trademarks and trade names other than its own.
Safety and Common Symbols

The following safety and common symbols may be used in this manual and on the equipment:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="DANGER" /></td>
<td><strong>DANGER</strong> indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.</td>
</tr>
<tr>
<td><img src="image" alt="WARNING" /></td>
<td><strong>WARNING</strong> indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.</td>
</tr>
<tr>
<td><img src="image" alt="CAUTION" /></td>
<td><strong>CAUTION</strong> indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.</td>
</tr>
<tr>
<td><img src="image" alt="CAUTION" /></td>
<td><strong>CAUTION</strong> used without the Caution, risk of danger sign, indicates a hazard with a potentially hazardous situation which, if not avoided, may result in property damage.</td>
</tr>
<tr>
<td><img src="image" alt="Caution, risk of electric shock" /></td>
<td>Caution, risk of electric shock</td>
</tr>
<tr>
<td><img src="image" alt="Caution, hot surface" /></td>
<td>Caution, hot surface</td>
</tr>
<tr>
<td><img src="image" alt="Caution, risk of danger" /></td>
<td>Caution, risk of danger</td>
</tr>
<tr>
<td><img src="image" alt="Caution, lifting hazard" /></td>
<td>Caution, lifting hazard</td>
</tr>
<tr>
<td><img src="image" alt="Caution, hand entanglement hazard" /></td>
<td>Caution, hand entanglement hazard</td>
</tr>
<tr>
<td><img src="image" alt="Notice, non-ionizing radiation" /></td>
<td>Notice, non-ionizing radiation</td>
</tr>
<tr>
<td><img src="image" alt="Direct current" /></td>
<td>Direct current</td>
</tr>
<tr>
<td><img src="image" alt="Alternating current" /></td>
<td>Alternating current</td>
</tr>
<tr>
<td><img src="image" alt="Both direct and alternating current" /></td>
<td>Both direct and alternating current</td>
</tr>
<tr>
<td><img src="image" alt="Three-phase alternating current" /></td>
<td>Three-phase alternating current</td>
</tr>
</tbody>
</table>
## Safety and Common Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Symbol" /></td>
<td>Earth (ground) terminal</td>
</tr>
<tr>
<td><img src="image2.png" alt="Symbol" /></td>
<td>Protective conductor terminal</td>
</tr>
<tr>
<td><img src="image3.png" alt="Symbol" /></td>
<td>Frame or chassis terminal</td>
</tr>
<tr>
<td><img src="image4.png" alt="Symbol" /></td>
<td>Equipotentiality</td>
</tr>
<tr>
<td><img src="image5.png" alt="Symbol" /></td>
<td>On (supply)</td>
</tr>
<tr>
<td><img src="image6.png" alt="Symbol" /></td>
<td>Off (supply)</td>
</tr>
<tr>
<td><img src="image7.png" alt="Symbol" /></td>
<td>Equipment protected throughout by double insulation or reinforced insulation</td>
</tr>
<tr>
<td><img src="image8.png" alt="Symbol" /></td>
<td>In position of a bi-stable push control</td>
</tr>
<tr>
<td><img src="image9.png" alt="Symbol" /></td>
<td>Out position of a bi-stable push control</td>
</tr>
</tbody>
</table>

We invite readers of this manual to send us their tips, feedback, and suggestions for improving the book.

Please send these to did@de.festo.com.

The authors and Festo Didactic look forward to your comments.
# Table of Contents

Preface ........................................................................................................................... VII  
About This Manual ....................................................................................................... IX  

**Work Order 1** Stuffing-Box Centrifugal Pump ...................................................... 1  
**Appendix A** Equipment Utilization Chart ................................................................. 17  
**Appendix B** Safety Procedures .................................................................................. 19  
**Appendix C** Types of Liquid Pumps .......................................................................... 21  
**Appendix D** Variable Speed Drive – Parameter Reference Table ......................... 23  
**Appendix E** Troubleshooting Chart ......................................................................... 25  
**Appendix F** Flexible Coupling Installation Procedure ............................................. 27
To the Instructor

NCCER Accreditation

Contact the National Center for Construction Education and Research (NCCER), at www.nccer.org, to obtain the requirements relative to the NCCER accreditation of this course.

Care and Maintenance of the Pumps Training System

Every week

- Check the general condition of the Pumps Training System.
- Check the condition of the snap-grip clamps on the hoses.
- Make sure the expanding work surface is solidly fixed on the bench. Check the condition of the four (4) push-lock fasteners.

Once a month

- Check the operation of the ground fault circuit interrupter (GFCI).
- Make sure that an O-ring is present and in good condition in each hose coupling.

Every 6 months

- Replace the water in the reservoir.
- Add the following solutions to the water in the reservoir:
  - 2 fl oz (60 ml) of Antibacterial solution, Lab-Volt p/n 38097
  - 8 fl oz (240 ml) of Rust inhibitor, Lab-Volt p/n 38096

Particular care required by the Stuffing-Box Centrifugal Pump

The housing and the impeller of the Stuffing-Box Centrifugal Pump are made of cast-iron; a material that tends to rapidly rust.

If the unit is going to sit longer than one week, the pump should be drained, and a layer of grease applied on all surfaces in contact with water (inner side of the casing and back plate, and both sides of the impeller). Spread the grease with a rag.

At the end of the procedure in this manual, the students are asked to apply the grease. You may decide to tell them to not apply the grease if another group is going to use the pump soon.
Sample Work Order
Extracted from
Stuffing-Box
Centrifugal Pump
Stuffing-Box Centrifugal Pump

Description

The Stuffing-Box Centrifugal Pump of your training system is shown in Figure 1-1. It consists of a centrifugal pump whose sealing is achieved by means of packing rings. The pump is attached to a bench for security and access purposes.

A stuffing box refers to a chamber that forms the region between the shaft and the casing where sealing media are installed. When the sealing is achieved by means of a mechanical seal, the chamber is commonly referred to as a seal chamber.

A typical stuffing box arrangement is shown in Figure 1-2. It consists of packing rings and a packing gland.
The function of the packing rings is to control leakage and not to eliminate it completely. A minimum flow out of the stuffing box must be maintained to lubricate the packing rings and to prevent overheating.

When the stuffing box pressure is below atmospheric pressure, a lantern ring is used to maintain lubrication.

The packing gland holds the packing rings and maintains the desired compression for a proper seal and flow.

**Mechanical seals versus packing rings**

In most cases, mechanical seals are better than packing rings. Some of the advantages of mechanical seals are:

- Mechanical seals consume less power than packing rings.
- Prevention of leakage which may lead to safety and cost issues.
- Mechanical seals can seal either vacuum or pressure.
- Unlike packing, mechanical seals do not have to be adjusted to compensate for wear.

**Applications**

In pulp and paper mills, stuffing-box centrifugal pumps are used for refiners, pulpers, separators, deflakers, stock pumps, coating pumps, vacuum pumps, agitators, condensate pumps, boiler feed and recirculation pumps, stock chests, mixers, steam vessels, liquor pumps. In steam, nuclear and hydro-electric plants, they are used for boiler feed water, boiler recirculation, condensate pumps, service water pumps, river
water intake, heater drain pumps, vacuum pumps, clinker grinders, fly-ash pumps, lime slurry pumps, auxiliary feed-water, and fire pumps.

**Maintenance**

The maintenance required by stuffing-box centrifugal pumps consists of:

- Adjusting the compression applied by the packing gland to maintain a proper seal and flow.
- Replacing the packing rings when fluid continues to flow out of the stuffing box when the pump is stopped.
- Inspecting and cleaning the components inside the stuffing-box centrifugal pump.
- Lubricating the pump as suggested by the manufacturer.
- Checking the pump to motor shaft alignment at regular intervals.

**Note:** An exploded view of the Stuffing-Box Centrifugal Pump is shown in Figure 1-3.

**Characteristics of the Stuffing-Box Centrifugal Pump of the training system**

- Maximum speed: 3500 r/min
- Maximum flow rate: 55 gal US/min (208 l/min)
- Maximum discharge pressure: 140 psi (980 kPa)
- Sealing element: packing rings
Stuffing-Box Centrifugal Pump

Task: To disassemble, inspect, lubricate, install, adjust the packing gland, operate, and troubleshoot a stuffing-box centrifugal pump.

PROCEDURE

CAUTION!

Before proceeding with this work order, complete the safety checklist in Appendix B.
1. Refer to Figure 1-3 to locate and identify the various components of the Stuffing-Box Centrifugal Pump.

Figure 1-3. Exploded view of the Stuffing-box centrifugal pump.

1  Screw
2  Casing
3  Cap screw
4  Lock washer
5  Impeller washer
6  Impeller
7  Casing gasket
8  Back plate
9  Packing rings
10 Packing gland
11 Washer
12 Grease fitting
13 Adjusting nut
14 Bearings
15 Spring retainer
16 Washer
17 Nut
18 Snap ring
19 Spring
20 Bracket
21 Bearing
22 End cap
23 Grease fitting
24 Screw
25 Key
26 Drain plug
27 Setscrew

Disassembly of the Stuffing-Box Centrifugal Pump

CAUTION!

Do not detach the pump from the bench. Many parts of the pump are heavy and must be handled with care.
2. Disassemble the pump as follows:
   - Drain the pump by removing the drain plug.
   - Remove the casing screws and the casing.
     
     **Note:** Be careful not to damage the casing gasket when removing the casing.
   - Remove the casing gasket.
   - Remove the cap screw and washers from the impeller.
   - Remove the impeller by screwing the casing screws in the three tapped holes around the diameter of the impeller (remove the shaft key).
   - Remove the nuts and washers from the packing gland and pull away the packing gland from the back plate.
   - Pull the back plate, packing gland, and washer off of the shaft.
     
     **Note:** Do not remove the packing rings from the back plate. Do not disassemble other components of the pump.
   - Loosen the setscrew and remove the adjusting nut by turning the nut counterclockwise using a spanner wrench.
   - Remove the end cap.

**Inspection**

3. Clean all components, remove all hardened residues, and the grease in excess in the adjusting nut and end cap (if applicable).

4. Look at the packing rings in the back plate.
   
   How many packing rings do you count in the back plate?
   
   _____

5. Check all components for wear.

   **Note:** Notify your instructor if any parts seem damaged.

**Reassembly of the pump**

6. Reassemble the pump as follows:
   - Install the adjusting nut by turning the nut clockwise using a spanner wrench.
   - Lock the adjusting nut into position by tightening the setscrew.
   - Install the end cap.
   - Mount the washer, packing gland, and back plate on the shaft.
   - Install the washers and nuts to attach the packing gland, do not tighten now.
   - Install the shaft key and the impeller.
• Install the casing gasket and casing, tighten the screws in an opposing sequence.

   **Note:** The casing gasket consists of 3 stacked gaskets.

• Make sure the shaft turns freely. If the impeller touches the casing, set the adjusting nut as follows:
  • Loosen the setscrew that locks the adjusting nut into position.
  • Tighten the adjusting nut until the shaft turns freely.
  • Loosen the adjusting nut while turning the shaft until the impeller touches the casing. The clearance of the impeller is now zero.
  • Tighten the adjusting nut approximately a quarter of a turn. The shaft should then turn freely with no evidence of scraping inside the pump. If scraping does appear evident then tighten another quarter turn.
  • Tighten the setscrew onto the adjusting nut to lock it into position.
  • Check the shaft rotation again.

**Lubrication**

☐ 7. Lubricate the pump as follows (for each fitting):
  • Make sure that the grease fitting is tightened firmly.
  • Wipe off the grease fitting and the grease coupler of the grease gun.
  • Press the grease coupler on the grease fitting until it snaps into place.

   **Note:** Make sure to use the grease supplied with the Lab-Volt Lubrication Kit, Model 46792.

  • Pump the grease. Do not over lubricate.
  • Disengage the grease coupler from the grease fitting.
  • Wipe off the grease from the fittings and grease coupler.

**Circuit setup**

☐ 8. Make sure the Stuffing-Box Centrifugal Pump is aligned on the bench. The distances shown in Figure 1-4 must be equal. Tighten the screws.
Figure 1-4. Make sure the pump is correctly aligned on the bench.

☐ 9. Install the flexible coupling as described in Appendix F.

**CAUTION!**

It could be dangerous to operate the pump if the procedure described in Appendix F is not followed. Ask your instructor to check your setup before starting the pump.

☐ 10. Install the coupling guard.
11. Set up the pumping circuit shown in Figure 1-5.

![Figure 1-5. Pumping circuit using the Stuffing-Box Centrifugal Pump.](image)

12. Connect the Variable Speed Drive and Motor using the cables supplied with the Stuffing-Box Centrifugal Pump.

13. Prime the pump.

**CAUTION!**

Never run the Stuffing-Box Centrifugal Pump dry.

14. Perform the following settings on the Variable Speed Drive:

- Set the maximum allowable Motor current to the full load amperes (FLA) rating shown on the Motor name plate (approximately 3.0 A).
- Set the direction of rotation to reverse.
- Set the maximum output frequency to 30 Hz.
- Turn the speed control knob fully clockwise.

**Note:** The speed of rotation of the pump is limited to 1800 r/min (output frequency of the Variable Speed Drive = 30 Hz) to take account of the driving motor capacity.

15. Open valve HV-4 and turn the relief valve control knob fully clockwise to block the alternate flow path.
Packing gland adjustment

☐ 16. Run the pump and set valve HV-4 to obtain approximately 14 psi (97 kPa) while observing if water leaks from the packing. It may take a few minutes before water starts to drip.

**Note:** If the Variable Speed Drive trips, loosen the packing gland: it may be too tight. If it still continues to trip, check the alignment and the setting of the adjusting nut.

**CAUTION!**

Do not adjust the packing gland while the pump is running.

☐ 17. Stop the pump, then adjust the pressure applied to the packing by screwing or unscrewing the packing nut to allow drippage of 4 to 10 drips per minute. Repeat the setting until you obtain the desired flow rate.

**Note:** Packing gland adjustment compresses or decompresses the packing rings to set the desired leakage for cooling and lubrication. When tightening the gland it is essential to ensure that the gland flange is parallel to the face of the stuffing box. If the gland is screwed on unevenly it imposes a greater pressure on the packing upon one side of the shaft, causing a side thrust.

Overtightening the packing gland will cause premature shaft wear and increased horsepower requirements, possibly resulting in overheating.

Flow rate versus speed

☐ 18. Determine the flow rate versus speed characteristics as follows:

- Open valve HV-4.  
- On the Variable Speed Drive, increase the output frequency from 0 to 30 Hz by increments of 2.5 Hz. For each setting, measure the flow rate and enter your results in Table 1-1.

<table>
<thead>
<tr>
<th>OUTPUT FREQUENCY (Hz)</th>
<th>2.5</th>
<th>5</th>
<th>7.5</th>
<th>10</th>
<th>12.5</th>
<th>15</th>
<th>17.5</th>
<th>20</th>
<th>22.5</th>
<th>25</th>
<th>27.5</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLOW RATE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1-1. Flow rate versus output frequency.
19. Plot the flow rate versus speed (30 Hz = 1750 r/min) curve in Figure 1-6.

Figure 1-6. Flow rate versus speed curve.

Head versus flow rate

20. Determine the head versus flow rate characteristics as follows:

- Open valve HV-4.
- On the Variable Speed Drive, set the output frequency to 15 Hz.
- Close valve HV-4 to increase the head by increments of 1 ft (0.3 m) from the current value until HV-4 is fully closed. For each setting, measure the flow rate and enter your results in Table 1-2.
- Repeat your measurements for an output frequency of 20 Hz.
Table 1-2. Head versus flow rate characteristics.

☐ 21. Stop the pump.

☐ 22. Plot the head versus flow rate curves in Figure 1-7.
Troubleshooting

☐ 23. By referring to the Troubleshooting Chart in Appendix E, identify three symptoms that a faulty suction may cause.

☐ 24. By referring to the Troubleshooting Chart in Appendix E, name thirteen possible causes for a low flow rate.

☐ 25. Ask your instructor to check your work. Ask if greasing the internal components of the pump is required.

Note: The housing and the impeller of the Stuffing-Box Centrifugal Pump are made of cast-iron; a material that tends to rapidly rust. Figure 1-8 shows the internal components of a pump that has not been used for 6 weeks (without grease).

If the unit is going to sit longer than one week, the pump should be drained, and a layer of grease applied on all surfaces in contact with water (inner side of the casing and back plate, and both sides of the impeller). Spread the grease with a rag.

Make sure to use the grease supplied with the Lab-Volt Lubrication Kit, Model 46792.
Figure 1-8. The internal components of a cast-iron pump after 6 weeks without protection.

☐ 26. Disconnect your setup, apply the grease (if required), and return the equipment to the storage location.

Name: _______________________________ Date: ________________

Instructor's approval: ________________________________