

**Industrial Maintenance**

# **Multi-Stage Vertical Centrifugal Pump**

**Courseware Sample**

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By the staff of Festo Didactic

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



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








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# Safety and Common Symbols

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

Symbol	Description
	<b>DANGER</b> indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
	<b>WARNING</b> indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
	<b>CAUTION</b> indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
	<b>CAUTION</b> used without the <i>Caution, risk of danger</i> sign  , indicates a hazard with a potentially hazardous situation which, if not avoided, may result in property damage.
	Caution, risk of electric shock
	Caution, hot surface
	Caution, risk of danger
	Caution, lifting hazard
	Caution, hand entanglement hazard
	Notice, non-ionizing radiation
	Direct current
	Alternating current
	Both direct and alternating current
	Three-phase alternating current

# Safety and Common Symbols

Symbol	Description
	Earth (ground) terminal
	Protective conductor terminal
	Frame or chassis terminal
	Equipotentiality
	On (supply)
	Off (supply)
	Equipment protected throughout by double insulation or reinforced insulation
	In position of a bi-stable push control
	Out position of a bi-stable push control

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

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The authors and Festo Didactic look forward to your comments.

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# To the Instructor

## **NCCER Accreditation**

Contact the National Center for Construction Education and Research (NCCER), at [www.nccer.org](http://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





Sample Work Order  
Extracted from  
Multi-Stage Vertical  
Centrifugal Pump



## Multi-Stage Vertical Centrifugal Pump

### Description

The Multi-Stage Vertical Centrifugal Pump of your training system is shown in Figure 1-1. It consists of a three-stage, tank mounted centrifugal pump with a mechanical seal. As shown in Table C-1 in Appendix C, a multi-stage vertical centrifugal pump is a dynamic pump.



Figure 1-1. Multi-Stage Vertical Centrifugal Pump with suction chamber.

### How it works

Liquid enters into the suction opening and enters the center of the first impeller. See Figure 1-2.

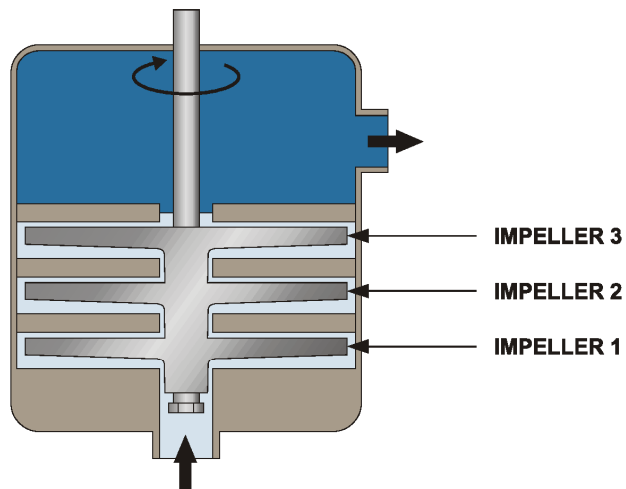


Figure 1-2. Fluid flow in a multi-stage vertical centrifugal pump.

Each successive centrifugal impeller directs its flow into the suction of the next impeller, which adds to the accumulated discharge head /pressure of the liquid.

As the liquid leaves the last impeller/stage it is directed toward the discharge port.

The Multi-Stage Vertical Centrifugal Pump of your training system is provided with a priming screw to facilitate the priming.

### **Advantages and disadvantages**

Advantages: multi-stage vertical centrifugal pumps are self priming and do not generate pressure pulsations. They are designed for low to high pressure, and very flexible as to installation length by adding empty chambers.

Disadvantages: they are suitable for clean, non-explosive liquids without abrasive particles or fibers.

### **Applications**

Multi-stage vertical centrifugal pumps are designed for pumping cooling lubricants for machine tools, condensate transfer, and other purposes. They are used for applications involving electrical discharge machine (EDM) tools, grinding machines, machining centers, cooling units, industrial washing machines, and filtering systems.

### **Maintenance**

The maintenance required by multi-stage vertical centrifugal pumps consists in inspecting and cleaning the components inside the pump at the intervals suggested by the manufacturer.

**Note:** *An exploded view of the Multi-Stage Vertical Centrifugal Pump is shown in Figure 1-3.*

### **Characteristics of the Multi-Stage Vertical Centrifugal Pump of the training system**

Number of stages: 3  
Maximum speed: 3450 r/min  
Maximum discharge pressure: 100 psi (700 kPa)  
Flow range: 1.8-26.5 gal US/min (6.8-100.3 l/min)  
Sealing element: mechanical seal

## Multi-Stage Vertical Centrifugal Pump

**Task:** To disassemble, inspect, assemble, install, operate, and troubleshoot a multi-stage vertical 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 Multi-Stage Vertical Centrifugal Pump.

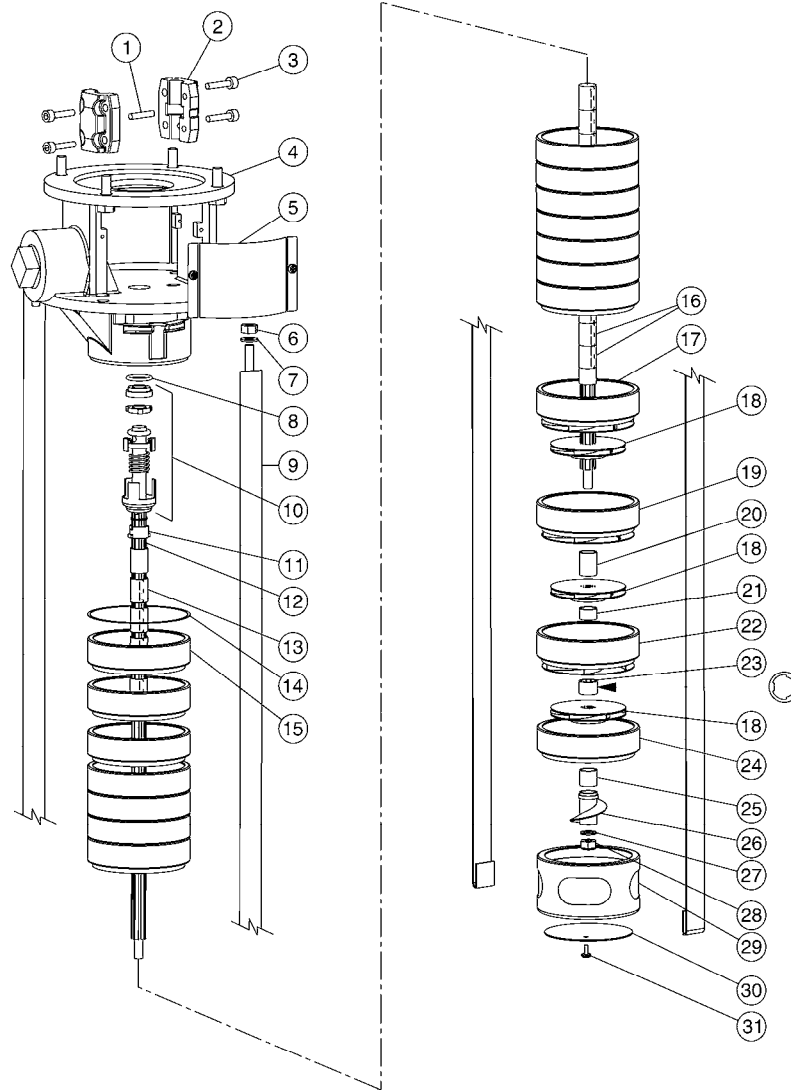


Figure 1-3. Exploded view of the Multi-Stage Vertical Centrifugal Pump.

- |    |                               |    |  |
|----|-------------------------------|----|--|
| 1  | Shaft pin                     | 15 | Intermediate chamber (x16)                             |
| 2  | Coupling half                 | 16 | Spacer 11/16 in (17 mm) (x2)                           |
| 3  | Screw                         | 17 | Intermediate chamber with flow path                    |
| 4  | Motor stool                   | 18 | Impeller   |
| 5  | Coupling guard                | 19 | Intermediate chamber with flow path and impeller guide |
| 6  | Nut                           | 20 | Spacer 13/16 in (20 mm)                                |
| 7  | Washer                        | 21 | Spacer 6/16 in (9 mm)                                  |
| 8  | O-ring                        | 22 | Intermediate chamber with flow path and bearing        |
| 9  | Retainer                      | 23 | Spacer (positioning guide)                             |
| 10 | Mechanical seal               | 24 | Intermediate chamber with large opening                |
| 11 | Spacer (positioning guide)    | 25 | Spacer 9/16 in (13.5 mm)                               |
| 12 | Spline shaft                  |    |  |
| 13 | Spacer 13/16 in (21 mm) (x16) |    |  |
| 14 | Gasket                        |    |  |

26	Priming screw	29	Suction chamber
27	Lock washer	30	Strainer
28	Nut	31	Screw

### Disassembly of the Multi-Stage Vertical Centrifugal Pump

- 2. Disassemble the pump as follows:
  - Remove the coupling guards (if applicable).



#### CAUTION!

Be careful when removing the components of the pump. The edges of some components are sharp. It is suggested to place the components side by side on the bench to facilitate the reassembly.

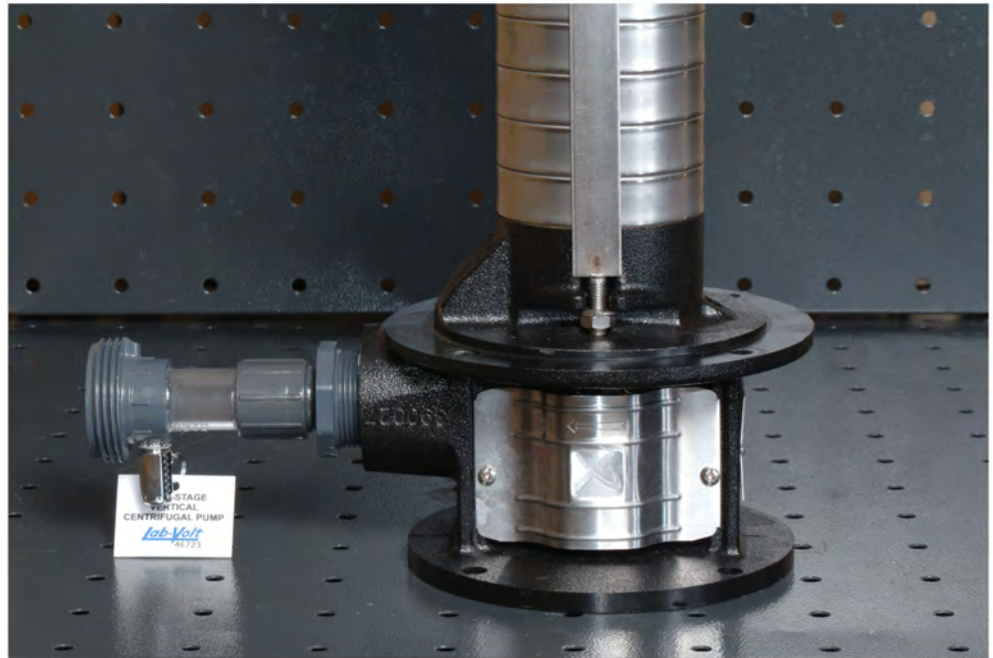


Figure 1-4. Place the pump upside down on a table.

- Remove the Motor (if applicable).
- Drain the pump.
- Place the pump upside down on the bench as shown in Figure 1-4.
- Loosen the nuts and remove the retainers.
- Remove the suction chamber.
- Remove the nut and lock washer at the end of the priming screw. Block the coupling if necessary.
- Remove the priming screw.
- Carefully remove the intermediate chambers, impellers, and spacers one by one.

- Be careful to not damage the gasket.
- Remove the coupling and shaft pin.
- Remove the spline shaft.
- Remove the mechanical seal.

### Inspection

- 3. Clean all components, remove all hardened residues.
  
- 4. Check the components as follows:
  - Inspect the pump components for excessive wear.
  - Inspect the mechanical seal for wear or crack.

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

### Reassembly of the pump

- 5. Reassemble the pump as follows:

**Note:** *The number between brackets refers to the numbers in Figure 1-3.*

- Install the mechanical seal. Check the orientation.
- Install the shaft pin and coupling.
- Install the spacer with positioning guide [11]. Check the orientation.
- Install the spacers 13/16 in (21 mm) (x16) [13].
- Install the spacers 11/16 in (17 mm) (x2) [16].
- Install the gasket.
- Install the intermediate chambers (x16) [15].
- Install an intermediate chamber with flow path [17].
- Install an impeller.
- Install an intermediate chamber with flow path and impeller guide [19].
- Install the spacer 13/16-in (20-mm) long [20].
- Install an impeller.
- Install the spacer 6/16-in (9-mm) long [21].
- Install the spacer with positioning guide [23].
- Install the intermediate chamber with flow path and plain bearing [22].
- Install an impeller.
- Install the spacer 9/16-in (13.5-mm) long [25].
- Install an intermediate chamber with flow path and impeller guide.
- Install the priming screw.
- Install the lock washer and lock nut.
- Install the suction chamber
- Install the retainers.



### Lubrication

**Note:** *The Multi-Stage Vertical Centrifugal Pump does not require special lubrication.*

### Circuit setup

- 6. Remove the cover plate on the work surface of the pump bench. See Figure 1-5.

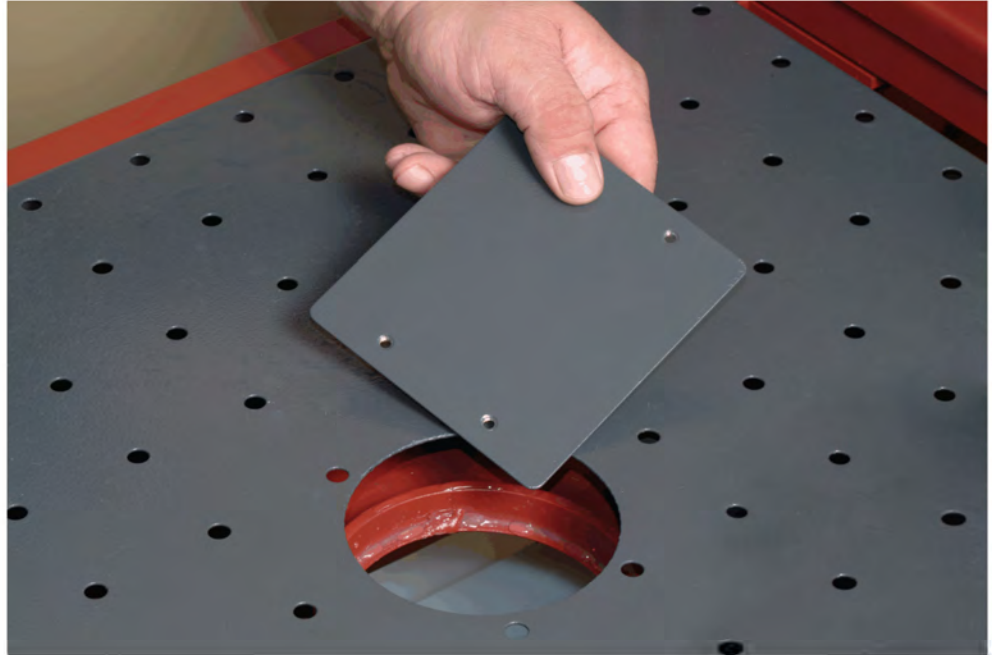


Figure 1-5. Remove the cover plate on the work surface.

- 7. Remove the cover of the reservoir.

- 8. Install the Multi-Stage Vertical Centrifugal Pump on the pump bench as shown in Figure 1-6.



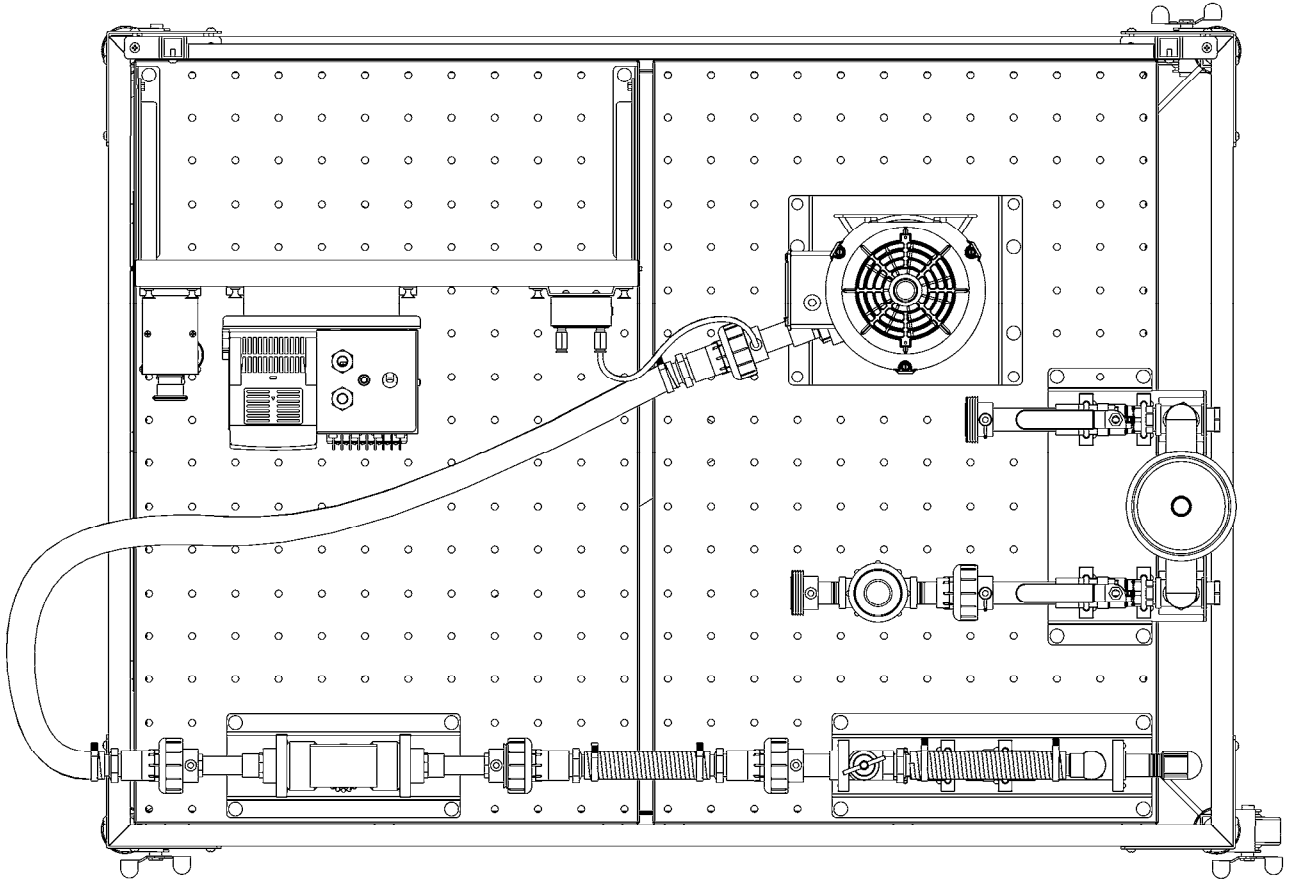
Figure 1-6. Installation of the Multi-Stage Vertical Centrifugal Pump on the pump bench.

- 9. Install and attach the Motor on the motor stool.
- 10. Tighten the coupling on the Motor shaft. Tighten the screws to a torque of 10 lbf·in (1.13 N·m). Make sure the gaps between the coupling halves are equal.

**Note:** *Slightly pull up the coupling with the tip of a screwdriver while tightening to prevent the coupling-shaft assembly from dragging on the motor stool. The coupling must turn freely.*

- 11. Install the coupling guards.

- 12. Set up the pumping circuit shown in Figure 1-7.



**Figure 1-7. Pumping circuit using the Multi-Stage Vertical Centrifugal Pump.**

- 13. Connect the Variable Speed Drive and Motor.
- 14. Perform the following settings on the Variable Speed Drive:
  - Set the maximum output frequency to 60 Hz.
  - Set the direction of rotation to forward.
- 15. Turn the control knob of the relief valve fully clockwise to block the alternate flow path.

**Flow rate versus speed**

- 16. 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 50 Hz by increments of 10 Hz. For each setting, measure the flow rate and enter your results in Table 1-1.

**Note:** The output frequency is limited to 50 Hz to not exceed the operating range of the Paddle Wheel Flowmeter.

OUTPUT FREQUENCY (Hz)	0	10	20	30	40	50
FLOW RATE						

Table 1-1. Flow rate versus output frequency.

- 17. Plot the flow rate versus speed (50 Hz  $\approx$  2875 r/min) curve in Figure 1-8.

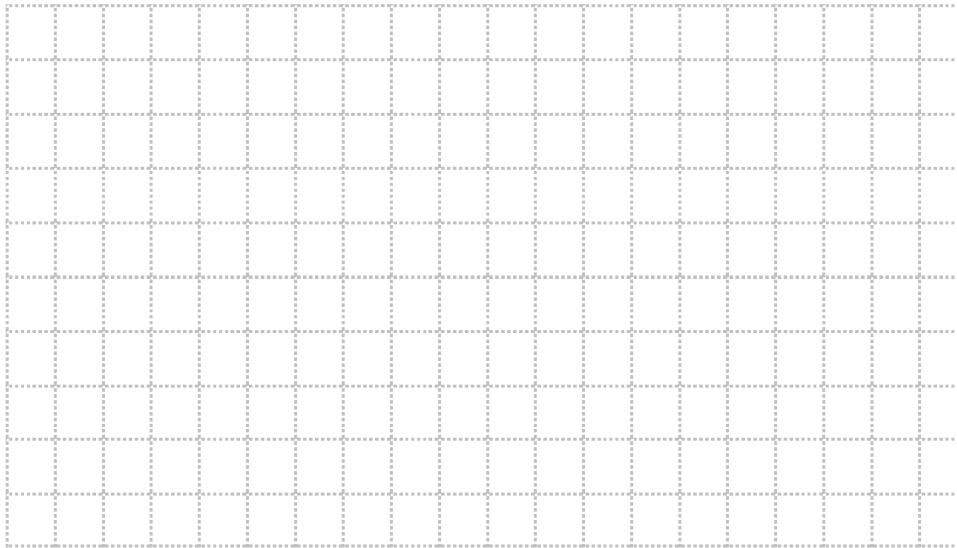


Figure 1-8. Flow rate versus speed curve.

**Head versus flow rate**

- 18. Determine the head versus flow rate characteristics as follows:
  - Make sure valve HV-4 is open.
  - On the Variable Speed Drive, set the output frequency to 30 Hz.
  - Close valve HV-4 to increase the head by increments of 5 ft (1.5 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 output frequencies of 40 and 50 Hz.

OUTPUT FREQUENCY					
30 Hz		40 Hz		50 Hz	
HEAD	FLOW RATE	HEAD	FLOW RATE	HEAD	FLOW RATE

**Table 1-2. Head versus flow rate characteristics.**

- 19. Stop the pump.

- 20. Plot the head versus flow rate curves in Figure 1-9.

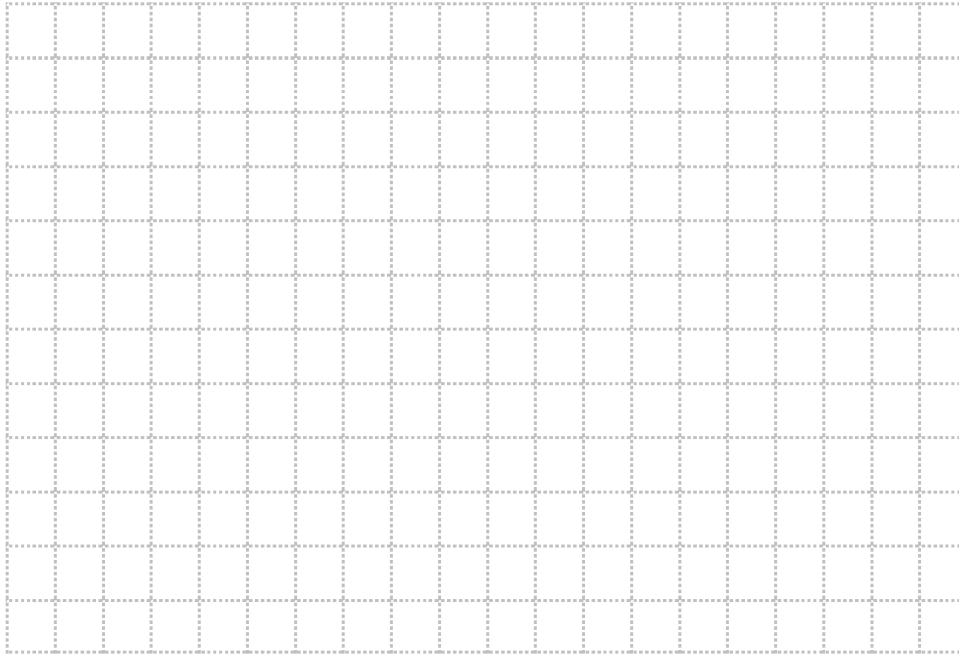


Figure 1-9. Head versus flow rate.

**Troubleshooting**

- 21. By referring to the Troubleshooting Chart in Appendix E, identify two symptoms that a pump rotating too slowly may cause.

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- 22. By referring to the Troubleshooting Chart in Appendix E, name seven possible causes for a low flow rate.

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- 23. Ask your instructor to check your work.
  
- 24. Disconnect your setup, clean the strainer, and return the equipment to the storage location.

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Instructor's approval: \_\_\_\_\_