Industrial Pump Learning System

Original Operating Instructions

Industrial Trades

User Guide

Festo Didactic
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Order no.: 8193214 (Printed version) 8193215 (Electronic version)
First Edition 2023/04
Revision level: 2026/03

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Printed in Canada

ISBN 978-2-89834-320-9 (Printed version)
ISBN 978-2-89834-321-6 (Electronic version)
Legal Deposit - Bibliothèque et Archives nationales du Québec, 2023
Legal Deposit - Library and Archives Canada, 2023

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Document Preliminaries

About this document

The operator should be familiar with the content of this document before installing and operating the equipment.

The Safety Symbols table at the beginning of this document lists safety symbols that may be present in this document or on the equipment.

This document is freely available for download from the Festo Didactic website.

Upon request, printed copies of this document are freely available. Contact your Festo Didactic sales representative.

Important. In this document, "the equipment" and/or "the learning system" specifically refers to the Industrial Pump Learning System.

This document contains the information required to set up, commission, and carry out maintenance on the equipment. However, for specific instructions or information, refer to the documents listed in the following table. These documents form the core of the documentation for the equipment.

Table 1: Core documentation.

Name	Part Number
Single-Pump Systems (workbook)	8195896 (SI units) 8176972 (US customary units)
Single-Pump Systems (workbook for instructors)	8195894 (SI units) 8176970 (US customary units)
Pump Performance (workbook)	8195715 (SI units) 8177349 (US customary units)
Pump Performance (workbook for instructors)	8195713 (SI units) 8177347 (US customary units)
Multiple-Pump Systems (workbook)	8195763 (SI units) 8190490 (US customary units)
Multiple-Pump Systems (workbook for instructors)	8195761 (SI units) 8185504 (US customary units)
External Gear Pumps (workbook)	8190918 (SI units) 8198522 (US customary units)
External Gear Pumps (workbook for instructors)	8190916 (SI units) 8198520 (US customary units)
Multistage Vertical Centrifugal Pumps (workbook)	8194640

Name	Part Number
Multistage Vertical Centrifugal Pumps (workbook for instructors)	8194638
Flexible Impeller Pump (workbook)	8194644
Flexible Impeller Pump (workbook for instructors)	8194642
Progressive Cavity Pump (workbook)	8197936
Progressive Cavity Pump (workbook for instructors)	8197934
Pneumatic Diaphragm Pump (workbook)	8197928
Pneumatic Diaphragm Pump (workbook for instructors)	8197926
Peristaltic Pump (workbook)	8205388
Peristaltic Pump (workbook for instructors)	8205386
Vane Pump (workbook)	8197924
Vane Pump (workbook for instructors)	8197922
Magnetic Drive Centrifugal Pump (workbook)	8197932
Magnetic Drive Centrifugal Pump (workbook for instructors)	8197930
Industrial Pump Learning System (user guide)	8193214

Safety Symbols and Procedures

The following table lists the safety and common symbols that may be used in this document and on the equipment. Before performing procedures with the equipment, you should read all sections regarding safety in the User Guide accompanying the equipment. Additional safety procedures are given before any task requiring specific safety precautions.

Symbol	Description
DANGER	**DANGER** indicates a hazard with a high level of risk, which, if not avoided, will result in death or serious injury.
WARNING	**WARNING** indicates a hazard with a medium level of risk, which, if not avoided, could result in death or serious injury.
CAUTION	**CAUTION** indicates a hazard with a low level of risk, which, if not avoided, could result in minor or moderate injury.
NOTICE	**NOTICE** indicates a hazard with a potentially hazardous situation, which, if not avoided, may result in property damage.
	Caution, risk of danger. Consult the relevant user documentation.
	Caution, risk of electric shock.
	Caution, lifting hazard.
	Caution, hot surface.
	Caution, risk of fire.
	Caution, risk of explosion.
	Caution, belt drive entanglement hazard.
	Caution, chain drive entanglement hazard.

Symbol	Description
	Caution, gear entanglement hazard.
	Caution, hand crushing hazard.
	Static sensitive contents. Observe precautions for handling electrostatic discharge sensitive devices.
	Notice, non-ionizing radiation.
	Consult the relevant user documentation.
	Radio Equipment Directive (RED) geographical restrictions – consult the relevant user documentation.
	Direct current.
	Alternating current.
	Both direct and alternating current.
	Three-phase alternating current.
	Earth (ground) terminal.
	Protective conductor terminal.
	Frame or chassis terminal.

Symbol	Description
	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.

General Requirements for Operating the Equipment

General requirements for safe operation of electrical equipment:

- National regulations for operating electrical systems and equipment must be observed in commercial facilities.
- The laboratory or classroom must be overseen by a supervisor.
    - A supervisor is a qualified electrician or a person trained in electrical engineering, who knows the respective safety requirements and regulations, and whose training is documented accordingly.
- Installation and commissioning of the equipment must be performed as directed in the accompanying documentation before any person can use the equipment for its intended purpose.
- Damaged or defective equipment must never be used.
    - Damaged devices must be barred from further use and removed from the laboratory or classroom.

Regulation in certain countries requires that the laboratory or classroom is equipped with the following devices:

- The ac power outlets in the laboratory or classroom must be protected by residual current devices (RCDs).
    - Electrical equipment (e.g., power supply units, compressors, hydraulic power units, etc.) may only be operated in training rooms which are equipped with residual current devices (RCDs).
    - Type A or type B residual current circuit breakers with a residual current set in accordance with the local regulation (generally ≤ 30 mA) must be used to protect the ac power outlets in the laboratory or classroom.

  The 230V version of the Industrial Pump Learning System (Part number 8180040) includes a type A, 30 mA residual current protective device. Make sure that the RCD selected at the installation point is compatible and follows coordination principles (also referred to as selectivity or discrimination) in accordance with local regulations.
- The ac power outlets in the laboratory or classroom must be protected by overcurrent protection devices.
    - Circuit breakers or fuses.

For more safety, the laboratory or classroom can also be equipped with the following devices:

- One or several energy-off devices can be provided.
    - An emergency-off device can be provided to turn electric power off for the whole laboratory or classroom.
    - An emergency-off device can be provided at each workstation to turn electric power off at the workstation only.
- The laboratory or classroom can be secured so that the operating voltage and compressed air supply cannot be activated by unauthorized persons, for example by means of:
    - Lockable power-on switches.

Use for Intended Purpose

The equipment may only be used:

- For its intended purpose in teaching and training applications.
- When its safety functions are in flawless condition.

The components of the equipment are designed in accordance with the latest technology and recognized safety rules. However, life and limb of the user and third parties may be endangered and the equipment may be impaired if it is used improperly.

The learning program from Festo Didactic has been developed and produced exclusively for training purposes. To ensure the safety of the trainees during their training, the training company and/or supervisors must make sure that all trainees use the equipment as directed in the accompanying Festo Didactic courses, and observe the safety instructions and precautions in the present document.

⚠ WARNING

Risk of danger from using the equipment in a way other than prescribed by Festo Didactic!

- Using the equipment in a way other than directed in the accompanying Festo Didactic courses, or using the equipment with equipment from other manufacturers, may increase the risk of danger for the users of the equipment.
- To minimize the risk of danger related to the situation described above, always respect the specifications marked on the equipment as well as the specifications in the Festo Didactic data sheet of the equipment.
- If the equipment includes a third-party component, always respect the specifications and directives provided in the user document on this component to minimize the risk of danger related to the situation described above.

Guarantee and Liability

Our "general terms and conditions of sale and delivery" are always applicable. These are made available to the operating company no later than on conclusion of the sales contract. Guarantee and liability claims resulting from personal injury and/or property damage are excluded if they can be traced back to one or more of the following causes:

- Use of the equipment for anything other than its intended purpose.
- Improper commissioning and/or operation of the equipment.
- Use of the equipment with defective safety equipment, or with improperly attached or non-functional safety and protective equipment.
- Non-compliance with instructions included in the core documentation about commissioning and operation.
- Unauthorized modifications to the equipment.
- Improperly executed repairs.
- Disasters resulting from the influence of foreign bodies and acts of nature.

Festo Didactic hereby excludes any and all liability for damages suffered by trainees, the training company, and/or any third parties, which occur during use of the equipment in situations which serve any purpose other than training and/or vocational education, unless such damages have been caused by Festo Didactic due to malicious intent or gross negligence.

Work and Safety Instructions

Safety responsibilities

Responsibilities are divided by role as shown in the following table.

Table 2: Responsibilities by role.

Role	Responsibilities
Operating company	• Allow only qualified personnel to work with the equipment. • Ensure personnel are trained in safety regulations and have read the safety information in this document. • Periodically evaluate personnel for safe working practices.
Instructor	• Supervise trainees at all times. • Permit only harmless mistakes and prevent actions that could cause injury or damage.
Trainees	• Read the safety chapter and warnings before use. • Follow all applicable work-safety and accident-prevention rules. • Work only under the supervision of a qualified person.

General operational safety

⚠ CAUTION

Ignoring basic operational safety rules may lead to accidents, injuries, or equipment damage.

- Trainees must be supervised by an instructor at all times when working with the equipment.
- Use the equipment only as instructed in Festo Didactic documentation.
- Keep switches, buttons, and disconnectors unobstructed and easy to reach.
- Repair or secure faulty equipment immediately.
- Wear suitable personal protective equipment (PPE), such as safety glasses and safety shoes.
- Avoid wearing loose clothing or accessories that could become entangled in equipment.
- Secure long hair to prevent it from interfering with moving parts or obstructing vision.
- Keep the work area clean, dry, and free of substances that could cause slips or interfere with equipment operation.

⚠ CAUTION

Improper handling of heavy equipment may cause personal injury or equipment damage.

- Use proper lifting techniques or assistance when moving heavy components marked with the lifting-hazard symbol.

Personal protective equipment (PPE)

Despite built-in safety features, residual risks remain due to misuse or faulty components. To reduce injury risk, always follow these PPE guidelines:

- Wear **safety shoes** when frequently moving equipment between storage and workstations.
- Wear **safety glasses** when working with polarized capacitors, which may explode unexpectedly.
- Wear **hearing protection** when using noisy equipment such as rotating machines.

- Wear **insulating gloves** when handling live electrical components.
- Wear **safety gloves** for mechanical handling (e.g., sharp edges, heavy parts, hot surfaces).

Equipment handling and layout

NOTICE

Cable handling

- Lay out cables without bends, pinches, or contact with hot surfaces (clearly marked if applicable).
- Always unplug by pulling the plug itself—never pull on the cable.
- Prevent continuous tension on cables to avoid damage and disconnection.

NOTICE

Ventilation and heat management

- Keep all ventilation slots unobstructed. Place equipment only on hard, flame-resistant surfaces to allow proper airflow.
- Do not install heat-generating equipment near or underneath temperature-sensitive components.

NOTICE

Workstation setup

- Check the maximum load capacity of the workstation and ensure it is not exceeded.

Electrical safety

⚠ WARNING

Risk of electric shock due to dangerous voltage

The equipment contains hazardous voltage that can cause death, serious injury, or major property damage if safety instructions are ignored.

Protective earth (PE)

- Always earth equipment fitted with a PE terminal.
- Connect the PE first and disconnect it last.
- Do not break or damage yellow-green PE conductors.
- Equipment with high leakage current needs a separate PE lead on its extra PE terminal.

Prohibited practices

- Never connect power sources in series.
- Never connect multiple power supplies to a single ac power wall outlet, as this can cause higher leakage currents.
- Do not exceed the input voltage or current rating of any device, as this can lead to heating, shocks, and fires.

Safe voltage limits

- Contact with > 30 V ac rms or > 60 V dc can be fatal.
- Shield power source outputs and leads from touch; use shrouded safety leads rated CAT II or higher.
- Switch off all power sources and de-energize circuits before wiring changes.
- Only use detachable mains supply cords, cables, and connection leads with adequate ratings.

Capacitors

- Large capacitors may stay charged after power-off. Wait several minutes before opening housings.

Low-voltage circuits

- Power low-voltage circuits only with Class II SELV or double-insulated supplies (e.g., Festo Didactic power sources).

Mechanical safety

⚠ WARNING

Risk of serious injuries due to moving parts in equipment!

- Always turn electric power off before mechanically coupling rotating machines.
- Always install the protective guard on the rotating machines to eliminate the risk of a serious injury caused by accidental contact with moving parts.
- Do not touch the equipment until all moving parts have come to a complete standstill.
- Tie back long hair.

⚠ WARNING

Risk of hand entanglement and skin abrasion if the equipment is operated without protective guard!

- Always install the protective guard on the rotating machines to eliminate the risk of hand entanglement and skin abrasion.

Risk of hand entanglement and skin abrasion if the equipment is operated with a damaged protective guard!

- Always inspect the protective guard before installation on the rotating machines to ensure that it is not damaged. Immediately remove any damaged protective guard from the laboratory or classroom.

⚠ CAUTION

The equipment may produce high sound pressure levels (≥80 dBA) in certain operating conditions (i.e., high motor speed, reverse motor operation, two-motor operation, multiple workstations operating simultaneously, etc.), which may cause discomfort, hearing impairment or headaches. Wear protective earpieces when operating the system in such conditions.

⚠ CAUTION

Some modules can become very hot when used for a long period of time. To prevent burn injuries, let them cool down before handling them.

NOTICE

- Always follow all instructions concerning the installation and positioning of rotating machines to ensure correct operation of these machines.
- Do not allow the pump to run dry. To prevent damage to the pump, always make sure its casing is filled with water before operating the pumping circuit.

Water safety

⚠ WARNING

Risks of electrical hazards when exposing the electrical panel of the workbench to external sources of water!

- The system bench offers protection from water spilling, leakage or bursts originating from the system itself. However, various guidelines must be followed to ensure it remains protected also from external water sources. The equipment is not protected against willful misuse, negligence and disregard of safety instructions.
- Do not place other hydraulic systems (such as another Industrial Pump Learning System) near the electrical panel at the back of the equipment.
- Always make sure that the electrical panel is dry and free of water before connecting cables. Do not make connections unless the connectors are completely dry.
- Place the protective cap on the unused motor connector when using only one motor-pump assembly.
- Do not power the equipment if there is water on the electrical panel or any connector.

⚠ CAUTION

- Before operating the pump, always make sure the camlock connectors and pressure ports are secured to prevent water splashing and spills.
- Stop the pump immediately if a camlock, a pressure port, a hose, or any other equipment of the pumping circuit is causing a leak, especially if water splashes in the direction of the motor or the control panel.
- Proceed with caution when disassembling the piping and when removing the pump cover, as there is still water in them.
- Wipe down any water spill on the floor to reduce tripping hazards.
- Do not fill the water tank at a level higher than the recommended amount (approximately 28 cm (11 in) below the perforated surface). Doing so may increase the risks of overflow and slipping hazards.

Cyber security

Festo Didactic provides products with security functions that support the safe operation of plants, systems, machines, and networks. Protecting these assets from cyber threats, however, requires a comprehensive and regularly updated security concept. Festo's products and services form only part of such a strategy.

The customer is responsible for preventing unauthorized access to equipment and networks. Connections to company networks or the Internet should be made only when necessary and only with appropriate security measures, such as firewalls, network segmentation, defense-in-depth strategies, etc.

Without these measures, connecting products to a network can expose vulnerabilities that allow unauthorized remote access, potentially affecting the entire system. This access can be exploited for data theft, manipulation, or sabotage. Common threats include Denial-of-Service attacks, remote code execution, privilege escalation, ransomware, and other malicious activities. In industrial environments, such attacks can create unsafe conditions, endangering both people and equipment.

Customers should follow Festo's security guidelines and keep their products up to date. Festo continuously improves its products for greater security and strongly recommends installing updates promptly. Using outdated or unsupported versions increases exposure to cyber threats.

Report security issues to the Festo Product Security Incident Response Team (PSIRT) in German or English by email at psirt@festo.com or through the online form at https://www.festo.com/psirt.

⚠ WARNING

Unsecure operating conditions due to software tampering

- Software tampering (e.g., viruses, Trojans, malware, worms) can cause unsafe system conditions, potentially leading to serious injury or property damage.
- Keep all software up to date.
- Integrate all automation and actuator components into a comprehensive industrial security concept aligned with current technological standards.
- Ensure all installed products are included in your security concept.
- Use protective tools, such as antivirus software, to scan files on removable storage media for malware.

⚠ WARNING

Firmware Update Security

This warning applies only to products with updatable firmware. To protect the security and integrity of your system, follow these guidelines during the firmware update process:

- **Download source.** Obtain firmware updates only from the official manufacturer's website.
- **Do not tamper.** Do not modify or interfere with the firmware update process.
- **Update process.** Strictly follow the firmware update instructions provided in the user guide.

Equipment Installation and Commissioning

Environmental requirements

The equipment is designed to be installed and stored indoors and must be operated in the following environmental conditions to ensure user safety:

- an altitude up to 2000 m (6560 ft)
- a temperature between 5°C and 40°C (41°F and 104°F)
- a maximum relative humidity of 80% for temperatures up to 31°C (88°F), decreasing linearly to 50% relative humidity at 40°C (104°F)
- mains supply voltage fluctuations which do not exceed ±10% of the nominal voltage
- transient overvoltages up to the levels of overvoltage category II
- temporary overvoltage occurring on the mains supply: 1500 V for 120 V mains and 2500 V for 230 V mains
- a pollution degree of 2 in accordance with IEC 60664-1

The word pollution used above refers to any addition of foreign matter, solid, liquid, or gaseous (ionized gases), that may produce a reduction of dielectric strength or surface resistivity.

Power requirements

The Industrial Pump Learning System (8180039) has the following requirements:

- AC power network voltage and frequency: 120 V – 60 Hz
- Full load current: 10 A
- Maximum current: 12 A
- Electrical installation: 1 phase configuration including neutral and earth wires, protected by a 15 A circuit breaker.

The Industrial Pump Learning System (8180040) has the following requirements:

- AC power network voltage and frequency: 220/240 V – 50/60 Hz
- Full load current: 6 A
- Maximum current: 8 A
- Electrical installation: 1 phase configuration including neutral and earth wires, protected by a 16 A circuit breaker.

Other Technical Specifications

System bench dimensions (8180039/8180040)

- Length: 1240 mm (50.61 in)
- Width: 761 mm (31.06 in)
- Height: 915 mm (37.35 in)

Learning system weight

- Total weight (with all the equipment and tank filled with water): 298 kg (656 lb)
- Single pump system equipment (excluding motor-pump assembly): 10 kg (22 lb)
- Long-coupled motor-pump assembly: 17 kg (37 lb)
- Pump performance equipment: 0 kg (0 lb)
- Multiple pump system equipment (excluding motor-pump assembly): 1 kg (2 lb)
- Short-coupled motor-pump assembly: 14 kg (31 lb)
- Positive displacement pump system equipment: 3 kg (7 lb)

Weight of the equipment by drawer (excluding storing racks):

- Top drawer: 3 kg (7 lb)
- Middle drawer: 6 kg (13 lb)
- Bottom drawer: 36 kg (79 lb)

Technical specifications of the motor-pump assembly (8180041 and 8180051)

- Operating voltage: 3AC 230/400 V

  (Operating voltage of the motor can reach 460 V, but VFD output and connectors are limited to 400 V)
- Full load current: 3.0 A
- Operating frequency: 60 Hz
- Output power: 750 W (1 hp)
- Full load efficiency: 78.5% (NEMA Premium / IE3)

Output ratings

- Motor (-X2 and -X3 on the back panel): 3-phase AC, 0-230/400 V, 3 A, 750 W, 0-60 Hz.
- Sensors (-X4 and -X5 on the back panel): 2 x DC 24 V, 0.5 A (each).
- Analog I/O (-X6 on the back panel): DC 0-10 V.
- Digital I/O (-X7 on the back panel): DC 0-24 V.

Technical specifications of the supplied electromagnetic flow meter (8180048).

Table 3: Electromagnetic flow meter specifications.

Parameter	Value
Manufacturer	ifm
Model	SM7621
Operating range	0.1 to 75 L/min (0.02 to 19.82 gal/min)
Temperature range	–20 to 60°C (–4 to 140°F)
Internal diameter	3/4 in NPT DN20
Accuracy	± 0,8%
Response time	0.25 s
Minimum conductivity	≥ 20 µS/cm
Pressure rating	1600 kPa (232 psi)

For more details, please refer to documentation provided by the manufacturer.

Technical specifications of the supplied pressure meter (8180049).

Table 4: Pressure meter specifications.

Parameter	Value
Manufacturer	Ashcroft
Model	DG25
Operating range	100 to 14 000 kPa (15 to 2000 psi)
Temperature range	–30 to 82°C (–20 to 180°F)
Internal diameter	1/4 in NPT
Accuracy	± 0,5%
Response time	0.25 s
Battery life	Minimum 2000 h

For more details, please refer to documentation provided by the manufacturer.

Handling the learning system

Be careful when moving heavier modules (such as the motor-pump assembly). Keep the module as close as possible to the waist, with the shoulders level. Never hold heavy modules at arm's length or away from the body. Keep your back straight.

Install heavier modules and components first, while the top surface of the system bench is free of obstacles.

Wear safety shoes when moving heavy modules and components.

Make sure that the space surrounding the system bench is clean and free of obstacles when installing modules and components.

Swivel casters

The learning system has sturdy swivel casters, which makes it easy to move around. However, to prevent accidents, lock the casters when you do not move the system.

Make sure that the four swivel casters are all in the locked position whenever the system bench is not being moved and especially when it is in use. To lock a caster, press on its foot brake as the two following figures show.

Figure 1: Press on the foot brake to lock the caster.

Figure 2: Caster in the locked condition.

Before moving the system bench

Before moving the system bench, always make sure of the following:

- All cables are disconnected from the system bench. Make sure the main switch is turned off before disconnecting cables.
- If moving the system bench requires the disconnection of the secondary PE conductor, have a qualified electrician reinstall the conductor at the new location before reconnecting the power cable.
- No cables or other obstacles are in the way.
- The drawers are closed and locked.
- The floor is clean and free of water.
- The water tank is empty. If not, follow the steps to drain the tank.
- Only unlock the casters after verifying that the surrounding area is safe and free of hazards.
- Never move the system bench during operation.
- Wear safety shoes when moving the system bench.
- Always be aware of your surroundings when moving the system bench.
- The learning system is heavy; use it and move it only on a flat floor.

Quick start

1. Make sure the power light on the control panel is turned off. If not, set the Main switch to the O (off) position.
2. Install the lockout and tagout devices in the Main switch and lock them with a padlock.
3. Place the required equipment to build the pumping circuit on the perforated surface atop the system bench. Components are secured to the surface using quick lock fixations using an included tool.

Figure 3: Quick lock fixations and tool.

When a component is unlocked, a small red plastic tab is visible on the fixation, like on the right in the picture. To lock a component, use the included tool to turn the fixation clockwise until the straight side is parallel to the side of the support, just like on the left of the picture. To unlock a component, turn the fixation counterclockwise until the red tab is visible.

Pump installation

1. Connect the motor to the variable-frequency drive. To do so, clip the metal end of the motor connector to its corresponding input in the back of the system bench.

2. The system bench has two electrical connections in the back for two motor-pump assemblies. If only one is in use, place the protective cap on the unused connector.

3. Connect the pump to the pumping circuit using the camlock connectors. They slip into each other and are secured using the two levers. They provide a waterproof connection that can be easily assembled and disassembled. Camlock connectors are locked when the two levers are pushed all the way to the female side of the connector.

NOTICE
When connecting the motor to the variable-frequency drive, make sure to lay the cable in a safe environment, so that it doesn't get damaged. Tuck the cable far from the rotating parts so that it doesn't move and roll around the rotating parts once the system will start.

Figure 4: Camlock connectors.

Running the system

1. Make sure that there are no loose objects present on the system bench. Make sure the coupling guard is screwed in place on the long-coupled motor-pump assembly.

2. Open the hand valve at the suction of the pump completely. Close the hand valve at the discharge of the pump completely.

3. Fill the casing of the pump with water to prime it. Unscrew the brass cap on the top of the pump casing with an Allen key. Pour water into the hole until the casing is filled. Screw the cap back on.

4. Remove the lockout and tagout devices from the Main switch.

5. Turn the power on by setting the Main switch to the I (on) position. Make sure the Power light on the control panel is turned on.

   If the Power light does not turn on, make sure that the protective device (RCD/GFCI and circuit breaker) switch at the back of the control panel is set to the upper (on) position and that the workstation is connected to an ac wall outlet.

6. Press the Safety Reset button.

7. Start the motor by pressing the Start button (green button) on the variable-frequency drive.

8. Slowly rotate the OK button in the clockwise direction until the motor runs at the desired speed.

9. Open the hand valve at the discharge.

10. Let the pump run for approximately 10 seconds.

11. Close the hand valve at the discharge.

12. Stop the motor by pressing the Stop button (red button) on the variable-frequency drive.

13. Turn off the system by setting the Main switch to the O (off) position.

14. Disassemble the setup and return the components to the storage location. Be careful of spills as the piping and the pump casing are full of water. There is a drip pan under the perforated surface that collects water and directs it back in the tank.

Operating the variable-frequency drive

To control the pump in your learning system, set the frequency on the Variable Frequency Drive (VFD) included in the bench. The motor's rotation speed, and thus the impeller's speed, directly changes with the frequency set on the VFD. The VFD's screen provides useful information about the motor during operation.

Figure 5: Variable frequency drive panel layout.

The VFD included in the system bench is a model of Sinamics V20 by Siemens.

The variable frequency drive has five buttons and a display screen, as the preceding figure shows. The panel layout of the variable frequency drive is described as follows.

- **Stop button.** Stops the drive.
- **Start button.** Starts the drive. Your drive is configured to start the motor rotation clockwise at 5 Hz.
- **Hand/Jog/Auto button.** Sets the drive to Hand, Jog, or Auto mode. If the Hand icon is flashing on the display screen, the drive is in Jog mode. If the Hand icon is continuously on, the drive is in Hand mode.

  Description of the three operation modes

  - In the Hand mode, the frequency of the drive can be modified while the motor runs, which modifies the speed of the motor. The Hand mode also permits reversing the direction.
  - In the Jog mode, the drive works continuously at a fixed speed and direction, independently from the system's settings. It is equivalent to an override switch in some systems. To properly use the Jog mode, the button must be pressed continuously.
  - Finally, in the Auto mode, the frequency of the drive is controlled by an external automation system.

- **OK button.** This button can be rotated clockwise or counter-clockwise to adjust the frequency accordingly. Pressing it cycles through the drive's display information, which includes drive output frequency (Hz), output voltage (V), output current (A), and dc voltage (V).
- **Function button.** Multi-function button that permits selecting a function and that can modify the digits of an item or access the setup menu.
- **Display screen.** Shows the units and status of the drive. The units are either in volts (V), amperes (A), or hertz (Hz). The status of the drive is indicated by status icons. The following table shows the status icons with their meanings.

Table 5: Status icons.

Icon	Description
	The drive has at least one pending alarm.
	The drive has at least one pending fault.
	The drive is running. When the icon is flashing, the drive may be energized unexpectedly.
	The motor rotates in the reversed direction.
	Indicates if the drive is in the Hand, Jog, or Auto mode.
	The drive is in the commissioning mode.

Procedure steps

1. To start the pump using the VFD, first plug the learning system in a wall outlet. Turn the system on using the rotating switch. The white Power On light should turn on.

2. As the blue Safety Reset light is on when powering the learning system, you will need to reset it by pressing the Reset button on the bench. Wait a few seconds to allow the VFD to boot.

3. By default, when the VFD is powered on, it is in Auto mode and the frequency setpoint is 5 Hz.

   Set the frequency of the VFD by turning the OK button.

   

   The pump is designed to work at 50 Hz for normal operation, but can be used at other frequencies when needed. Setting the frequency at a negative value makes the motor and impeller rotate in reverse direction. This should not be used in normal operation, unless instructed otherwise.

4. The drive starts when pressing the green "|" button.

   The pump can be stopped using the red "O" button.

Bump test

A bump test checks if the motor connected to the pump rotates correctly. To perform it, briefly turn on the motor, usually for one second. Follow these steps to conduct a bump test on the learning system:

1. Press the Hand/Jog/Auto button to reach the Jog mode. The hand icon flashes on the screen when the VFD is in this mode.

2. Press the green "|" button to start the pump at 5 Hz in its normal direction for one second. Hold the button down to make the pump run continuously.

   Check the rotation direction and make sure it is correct.

3. Press the Hand/Jog/Auto button to return to Auto mode.

Drive parameters

The following procedure explains how to set a parameter on the VFD:

1. Press the function (M) button for less than 2 seconds to access the parameter menu.

2. Rotate the OK button to reach the first parameter. Press OK.

3. Rotate the OK button to set the value of the parameter. Press OK.

4. Repeat the process for the other parameters if required.

5. Hold down the function (M) button continuously to exit the parameter menu.

Table 6: Parameters visible in the parameter editing mode.

Parameter	Function	Description
P0003	User access level	Displays the user access level.
P0005	Parameter display selection	Adds a measurement that can be displayed on the VFD screen (see below).
P0010	Commissioning parameter	This parameter must be set to 0, otherwise the motor will not start.
P0012	reserved	For commissioning only.
r0032	Actual filtered power	Displays the electrical power consumed in kW.
r0035	Actual motor temperature	Displays the calculated motor temperature. An algorithm calculates the temperature. It considers various parameters such as the torque and how long the motor has been running.
P0810 P0811	Mode of operation	Allows to switch between three modes of operation: using the VFD interface, with an external controller via the PNP/NPN or RS485 connector.
P0820	Inverter control mode	Allows to switch between two control modes (see below).

Parameter display selection

Setting a value to parameter P0005 allows the user to choose a measurement to be shown on the display of the VFD. Once a value is set for this parameter, the corresponding measurement will be the first to be display on the VFD screen.

For example, setting a value of 32 to parameter P0005 shows the electrical power supplied by the VFD. Setting the parameter to 0 deactivates this feature. Read the manufacturer's documentation on the VFD to look up the possible values and the corresponding measurements.

Inverter control mode

Parameter P0820 lets the user chose between two control modes for the VFD. The two modes are used for different types of pumps. They differ by the relation used to determine the voltage sent to the motor according to the frequency setpoint (V/F).

- **P0820 = 0** uses a quadratic relation between voltage and frequency. It is used with **centrifugal pumps**.
- **P0820 = 1** uses a linear relation between voltage and frequency. It is used with **positive-displacement pumps**.

Operation mode

The VFD can be controlled either directly through its interface panel or through an external controller. It is uncommon to use an external controller with the learning system. However, if it is required, the following table indicates the parameter values required to switch to external control.

Once the VFD is set to be controlled by an external controller, you cannot set its frequency set point, unless you switch to Hand mode. This bypasses the external controller.

Table 7: Parameter values required to switch to external control.

Parameter	Direct control (default)	External control M12	External control RS485
P0810	0	1	0/1
P0811	0	0	1

Table 8: External control connectors pin map.

Connector	# Pin	Color	Drive
 Figure 6: RS485 connector.	3	RED	P+
	5	WHI	0 V
	8	BLK	N-
	SH	SH	PE3
 Figure 7: Analog I/O, 8-pin M12 connector.	1	WHI	10 V
	2	BRN	AI1
	3	GRN	AI2
	4	YEL	AO1
	5	GRY	0 V

Connector	# Pin	Color	Drive
 Figure 8: Digital I/O, 12-pin M12 connector.	1	BRN	DI1
	2	BLU	DI2
	3	WHI	DI3
	4	GRN	DI4
	5	PNK	24 V
	6	YEL	0 V
	7	BLK	DIC
	8	GRY	DO1+
	9	RED	DO1-
	10	VIO	DO2-NC
	11	GRYPNK	DO2-NO
	12	REDBLU	DO2-C

Safety mechanism

In addition to standard protection, your learning system's drive is set up to safeguard the motor and pump with temperature protection.

An algorithm estimates the motor winding's temperature and shuts it down if the temperature exceeds the set limit. The maximum temperature is 118°C or 244°F.

The motor does not stop automatically when the estimated temperature hits the limit. Instead, the drive shows a warning (A511). If the temperature rises 10% more (e.g., 130°C or 268°F), the motor stops and the drive enters fault mode (F11).

NOTICE

Risks of burn when touching the frames of motors under fault!

- Motors may become very hot under fault conditions.
- Do not touch motor frames when the drive displays a temperature warning (A511) or fault (F11). Wait for the motors to cool down.

If the drive shows an overheating fault (F11), simply turning it off won't clear the fault because the estimated temperature is stored in the drive. You can check this temperature using parameter r0035. To reset the fault, keep the drive on with the motor stopped, allowing it to cool down. This enables the algorithm to lower the calculated temperature. Turning off the drive prevents the algorithm from calculating cooling time, so it assumes the motor temperature remains high. It takes a few hours for the estimated temperature to reach a safe level.

Common fault and alarm codes

The variable frequency drive displays codes when specific faults and alarms occur. The following table shows the most common fault codes. The next table shows the most common alarm codes.

All fault codes are listed in the manufacturer documentation of the variable frequency drive.

Table 9: Common fault codes.

Fault	Description
F1	Indicates an overcurrent.
F2	Indicates an overvoltage.
F3	Indicates an undervoltage.
F4	Indicates an inverter overtemperature.
F11	Indicates a motor overtemperature.
F41	Indicates a motor data identification failure.
F85	Indicates an external fault.
F101	Indicates a stack overflow.
F452	Indicates a belt failure.

The main difference between faults and alarms is that faults can be cleared without correcting the issue. An alarm cannot be cleared as long as the issue has not been rectified.

All alarm codes are listed in the manufacturer documentation of the variable frequency drive.

Table 10: Common alarm codes.

Alarm	Description
A501	Indicates a current limit.
A502	Indicates an overvoltage limit.
A503	Indicates an undervoltage limit.
A504	Indicates an inverter overtemperature.
A511	Indicates a motor overtemperature.
A535	Indicates a braking resistor overload.
A922	Indicates no load is applied to the inverter.
A952	Indicates a belt failure.

Priming the pump

The present procedure must be performed while the pump is stopped. Make sure there is no leak on the pumping casing or at the suction of the pump before proceeding.

1. To prime the pump, unscrew the brass plug on top of the pump casing. Use a 3/16" Allen key.

2. Pour water into the hole of the brass plug. You may find a funnel to be useful at this point.

3. Slowly pour until the pump casing is completely filled. Screw the brass cap back in place.

Figure 9: Brass plug used to prime the pump.

4. Start the pump using the Pump start-up and test procedure.

Priming the pump.

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Aligning the coupling between the motor and the pump

Flexible coupling alignment

The following procedure is a simple method to align the shafts of the motor-pump assembly using a straightedge (or level), a caliper, and a feeler gauge. It applies to all pumps of the Industrial Pumps Learning Systems using a flexible coupling, including the long-coupled centrifugal pump of the main series and most optional pumps included in the learning system.

For the pumps using a tang boot coupling (notably the peristaltic pump), see the dedicated subsection further in this procedure.

1. Roughly place the two hubs at the right place for alignment. Each hub is placed near the end of its shaft, and the rubber sleeve between the two. The setscrew of each hub is placed on the flat side of the key on its shaft.

   Tighten the setscrews on each hub.

2. Place the straightedge or level on top of the pair of hubs (position at 12 o'clock). Use the feeler gauge to measure the vertical parallel misalignment by inserting progressively thicker blades between the straightedge or level and one of the hubs, until the gap is filled. Proceed like shown in the following figure. Note this measurement.

Refer to the following video if necessary.

Figure 10: Straightedge and feeler gauge.

3. The vertical parallel gap corresponds to the shim thickness required under all motor feet. Add one or more shims if the vertical gap is larger than 0.38 mm (0.015 in). Install the same shim thickness on all feet. When shimming the motor feet, follow these guidelines:

   - Unscrew only two of the motor feet at a time.
   - Use as few shims as possible.
   - Do not assume the thickness of the shims. Measure each shim combination with a micrometer if available to ascertain its exact thickness.

4. Repeat the measurement on both sides (3 o'clock and 9 o'clock positions). Adjust the horizontal position of the motor relative to the pump accordingly. The motor must be moved if the gap is larger than 0.38 mm (0.015 in).

5. When you have finished shimming and moving the feet, retighten all screws. The motor shaft should now be roughly aligned with the pump shaft on both parallel planes. To confirm this, you can repeat the previous steps and make sure the measured gap is smaller than the maximal tolerated value.

Measuring the parallel misalignment.

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6. Use the caliper and the feeler gauge to measure the angular misalignment of the coupling. Find the point where the two couplings are the more spaced out. Place the caliper across the width of this side of the coupling and adjust its width to fit

this measurement. Measure the gap between the caliper and the coupling on the other side with the feeler gauge. Proceed like shown in the next figure. Note this measurement.

Refer to the following video if necessary.

Figure 11: Angular misalignment measurement – Top.

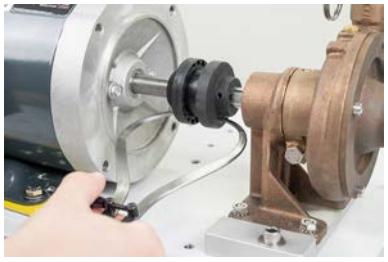

Figure 12: Angular misalignment measurement – Bottom.

7. If the measured gap is larger than 1.42 mm (0.056 in), add shims under two of the motor feet to reduce the angular misalignment. If the gap is on the bottom of the coupling, add a shim on the feet of the motor closest to the coupling. If the gap is on the top of the coupling, add a shim on the feet of the motor farthest away from the coupling.

8. When you have finished the angular adjustments, retighten all screws. The motor shaft should now be adequately aligned with the pump shaft. To confirm this, you can repeat the previous steps and make sure the measured gap is smaller than the maximal tolerated value.

   When the alignment is completed, tighten the screws of the motor and the pump in a criss-cross pattern. Screw the coupling guard over the coupling.

Measuring the angular misalignment.

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Tang boot coupling alignment

Alignment of the tang boot coupling is similar to the flexible coupling, but the small space between the pump and the motor creates an additional challenge.

1. Screw the coupling hub on the key in the keyway on the shaft of the motor. Place the tang boot in the slot of the coupling hub.

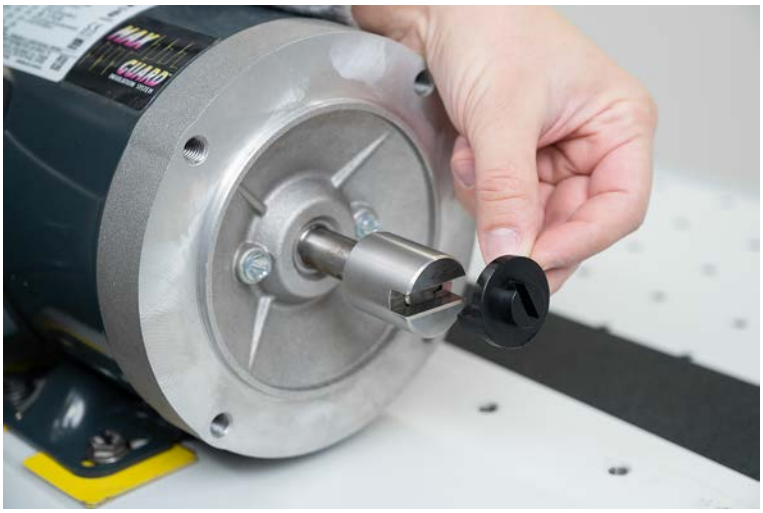

Figure 13: Coupling hub and tang boot.

2. Place the pump assembly (pump (tubing loaded) with its L base) on the baseplate and screw it in.

   Rotate the assembly so that the slot of the coupling is vertical.

3. Compare the position of the tang boot relative to both coupling hubs. Measure the length of the tang boot that protrude on each side of the coupling hub and compare these measurements. This gives you a good idea of the vertical misalignment.

   If the protrusion is greater on the bottom of the hubs, add a shim on the feet of the motor closest to the coupling. If the protrusion is greater on the top of the hubs, add a shim on the feet of the motor farthest away from the coupling.

Follow the same guidelines as previously when shimming the motor feet:

- Unscrew only two of the motor feet at a time.
- Use as few shims as possible.
- Do not assume the thickness of the shims. Measure each shim combination with a micrometer if available to ascertain its exact thickness.

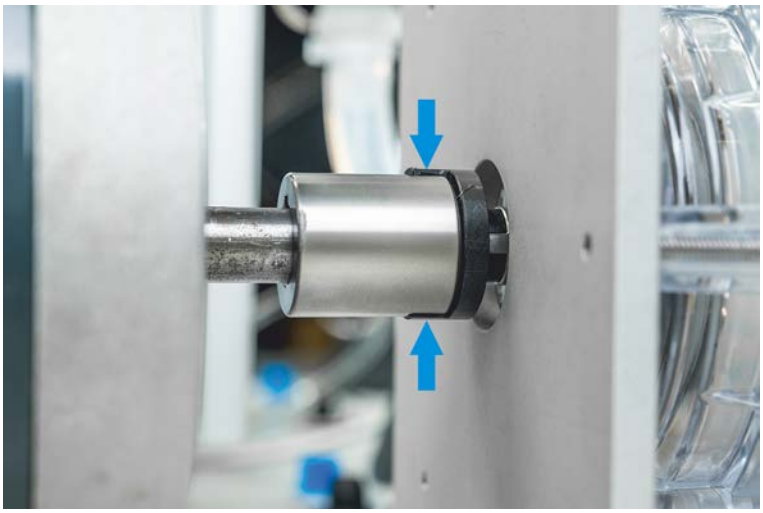

Figure 14: Compare how much the tang boot protrudes on each side of the coupling hub.

4. Rotate the assembly so that the coupling slot is horizontal.

   Repeat the last steps to evaluate the horizontal misalignment. Adjust the horizontal position of the motor accordingly.

5. When you have finished the position and shimming adjustments, retighten all screws. The motor shaft should now be adequately aligned with the pump shaft. To confirm this, you can repeat the previous steps and make sure the measured protrusion is consistent on each side.

Figure 15: Measure the protrusion of the tang boot in vertical and horizontal positions (here with a digital caliper).

Operating the electromagnetic flow meter

Instead of the rotameter, students can use an electromagnetic flow meter to read the flow of water in the pumping circuit. This allows for an easy and direct reading. The following figure shows the interface of the flow meter included in the learning system.

- The display shows the measurement of the flow and the selected unit of measurement.
- There are two buttons with up and down arrows (▲ and ▼) and a round enter button (●).
- The flow meter is connected to the pumping circuit using camlock connectors. It includes pressure ports to measure the pressure at either ends of the equipment.

Figure 16: Flow meter interface.

The flow meter turns on automatically when it is plugged to the system bench and the main switch is turned on. The connection is made using this 5-pin connector on the back of the system bench, as the following figure shows.

Figure 17: 5-pin connector.

Changing the unit of measurement

By default, the flow meter is set to display the flow rate in gal/min. To change this, follow these steps:

1. Press the ● button to get to the menu.
2. Using the ▲ and ▼ buttons, select EF (extended functions). Press ●.
3. Select cFG (configuration). Press ●.

   Select unF (flow rate unit). Press ●.
4. Hold down ▼ for more than 1 second to change the unit displayed.

   Select the measurement unit with ▲ and ▼. Confirm with ●.
5. Press ▲ repeatedly to return to the flow rate display.

Changing the orientation of the display

This flow meter can be installed upside down to measure the flow of water moving downwards. The orientation of the display needs to be changed so the user does not have to do a headstand to read the flow rate. To change this, follow these steps:

1. Press the ● button to get to the menu.
2. Using the ▲ and ▼ buttons, select EF (extended functions). Press ●.
3. Select DIS (display). Press ●.

   Select diS.R (display rotation). Press ●.
4. Hold down ▼ for more than 1 second to change the orientation.

   Select 180° (for upside down) or 0° (for the normal orientation) with ▲ and ▼. Confirm with ●.
5. Press ▲ repeatedly to return to the flow rate display.

Technical specifications of the supplied electromagnetic flow meter

For more details, please refer to documentation provided by the manufacturer.

Table 11: Electromagnetic flow meter specifications.

Parameter	Value
Manufacturer	ifm
Model	SM7621
Operating range	0.1 to 75 L/min (0.02 to 19.82 gal/min)
Temperature range	–20 to 60°C (–4 to 140°F)
Internal diameter	3/4 in NPT DN20
Accuracy	± 0,8%
Response time	0.25 s
Minimum conductivity	≥ 20 µS/cm
Pressure rating	1600 kPa (232 psi)

Operating the pressure meter

In replacement to the pressure gauge, the user of this course can use an electronic pressure meter to read the pressure in the pumping circuit. This allows for an easy and direct reading. Here is the interface of the pressure meter included in the learning system:

Figure 18: Pressure meter interface.

The display shows the measurement of the pressure and the selected unit of measurement. There are three buttons on the meter:

- Power/Enter
- Zero/▲
- Menu/▼

The pressure meter is connected to the pumping circuit using pressure ports. It is secured to the perforated surface using quick lock fixations.

The pressure meter is powered by two AA batteries. It can work independently of the system bench.

To turn on the meter, hold down the Power/Enter button for at least two seconds. Do the same to shut it down. As the pressure meter is powered by batteries, it is important to shut it down when you are done using the learning system so that they do not empty themselves too fast.

Setting the zero and changing the unit

The Zero/▲ button allows the user to set the zero of the pressure meter. As the meter reads a relative pressure, it can be necessary to set the zero to get accurate measurements. To do so, hold down the Zero/▲ button for at least 2 seconds.

By default, the pressure meter is set to display the pressure in psi. To change this, follow these steps:

1. Hold down the Menu/▼ button for at least 2 seconds.

   The word "UNITS" should be flashing on the display. Press Power/Enter.

2. Select the measurement unit with ▲ and ▼. Confirm with Power/Enter.

Filling the pressure lines

It is a good practice to fill the pressure lines with water when operating the pumping circuit. This reduces instability and ensures accuracy of measurement. This is because air in the pressure lines can be compressed while water cannot.

1. To purge the air out of the pressure line and fill it with water, plug it in the pressure meter at one end and into the discharge of the pump at the other end.

2. Start up the pump. Unplug the pressure line from the pressure meter for less than one second and plug it back in. This should take just enough time so the air can be purged out and water start to flow out.

Technical specifications of the supplied pressure meter

For more details, please refer to documentation provided by the manufacturer.

Table 12: Pressure meter specifications.

Parameter	Value
Manufacturer	Ashcroft
Model	DG25
Operating range	100 to 14 000 kPa (15 to 2000 psi)
Temperature range	–30 to 82°C (–20 to 180°F)
Internal diameter	1/4" NPT
Accuracy	± 0.5%
Response time	0.25 s
Battery life	Minimum 2000 h

Equipment Description

List of part numbers

Here are the parts included with the courses of the Industrial Pump Learning System. Refer to the Equipment Utilization Chart of any specific course for the parts required to complete each of the exercises.

Conserve all packing lists supplied with the equipment! Should any part be damaged or need replacement, contact your Festo Didactic representative using the part numbers on these documents.

Use only Festo Didactic parts and accessories to ensure compatibility and sustainability of the equipment.

Part number	Equipment
8180039/8180040	Pumping system bench
8180041	Motor-pump assembly (Long-coupled)
8180043	Ball valve
8180044	Globe valve
8180045	Pressure gauge
8180046	Rotameter
8180048	Electromagnetic flowmeter
8180049	Pressure meter
8180051	Motor-pump assembly (Close-coupled)
8180053	Check valve

Part number	Equipment
8180055	Positive-displacement pump accessories
8180056	External gear pump
8184314	Plastic cup
8184413	Suction support
8184414	Discharge support
8184415	Vertical support
8184416	Suction assembly
8184417	Discharge assembly
8184418	U-shaped pipe
8184419	Flexible hose
8184484	Y adapter in
8184485	Y adapter out
8184486	90° adapter
8185571	Transparent pump cover
8185572	Small impeller
766932	Pressure line hose
777852	Spare mechanical seal
Optional pumps	
8198312	Flexible impeller pump
8198313	Progressive cavity pump
8198314	Pneumatic diaphragm pump
8198315	Peristaltic pump

Part number	Equipment
8209794	Multistage vertical centrifugal pump
8209795	Vane pump
8209796	Magnetic drive centrifugal pump
Parts for fault insertion	
534682	Air valve
8184568	Pipe restriction
8184570	0.2 mm split stainless steel ring
8184572	1 mm split stainless steel ring
Tools	
582164	Quick lock tool
776183	Straightedge
780944	Feeler gauge set
781464	½ in combination wrench
792478, 776155, 776156, 776157	Shims set, 0.002 in to 0.020 in
8109588	Allen keys set
8128339	Outside caliper
8184343	Large mandrel
Lockout-Tagout kit	
781250	Lockout hasp
781251	Padlock
776151	Danger tag

The pumping system bench is available in two versions:

- 8180039 is rated for 120 V and 60 Hz.
- 8180040 is rated for 220/240 V and 50/60 Hz.

Degrees of ingress protection (IP)

The equipment is rated IP20.

NOTICE
The equipment is not protected against liquid infiltration or immersion. Keep it away from all types of liquids. Failure to do so could damage the equipment.

Part description of the Industrial Pump Learning System

Pump system bench

The system bench is the main part of the learning system, serving as the work surface for hands-on learning. It provides storage for the system's components and houses the electrical circuitry for the Variable Frequency Drive (VFD), which controls the pump. More information on the VFD is available in Learning Unit 5.

The top surface of the system bench is perforated to secure the pump circuit components. These components are fixed using quick-lock fixations with an included tool. Refer to the subsection on tools later in this section. A drip pan beneath the perforated surface collects water and directs it back into the tank.

Figure 19: Pump system bench.

The top drawer of the system bench contains a black plastic work surface that can be pulled out and attached to the perforated surface. It is designed for pump maintenance and includes a depression to hold screws and small parts, preventing them from falling through the holes or getting lost.

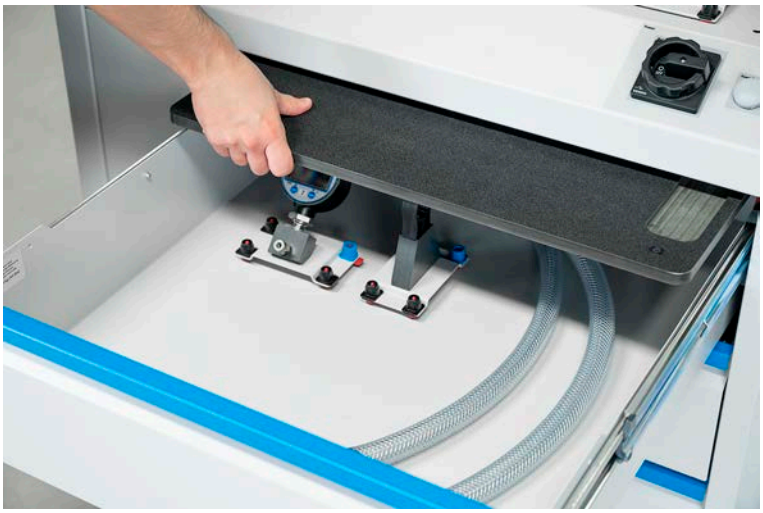

Figure 20: Work surface in the drawer.

The water tank is on the right side of the bench and can be removed for easy draining and cleaning. For more details about the water tank and maintenance tips, refer to Learning Unit 8.

It must be filled with regular tap water up to 30 cm (12 in) from the perforated surface, or 5 cm (2 in) above the tank valve.

Figure 21: Water tank side of the system bench.

System bench front panel

The following figure shows the front panel of the system bench, which includes the pump control buttons. The large rotating knob is the Main Switch used to power the system bench on and off. This is also where lockout/tagout devices are installed when required.

The Power On white light indicates when the learning system is powered.

Press the Reset button to perform a safety reset of the system when its blue light is on.

Next to these controls is the interface of the variable frequency drive (VFD), which controls the pump motor.

Set the drive frequency and navigate through its menus using the OK button. Adjusting the frequency changes the pump speed. By default, the frequency is set to 5 Hz. Unless otherwise specified, always use a positive frequency value to ensure the pump rotates in the correct direction.

Start the pump with the green "|" button and stop it with the red "O" button.

For more information on the VFD and its operation, see Learning Unit 5.

On the far right of the front panel, the Emergency Stop button can be used in emergencies. It does not fix issues automatically; it only shuts down the pump(s). Press the button to activate it and turn it to the left to reset it.

NOTICE

If a factory reset is performed on the variable frequency drive (VFD), all parameters will be deleted, which may lead to equipment damage.

Figure 22: System bench front panel.

Motor-pump assembly

The main pump in most exercises is a long-coupled centrifugal pump made of bronze, featuring a bronze open impeller. A removable plug on top allows for filling the casing to prime the pump.

The assembly contains the pump, the motor, and the coupling, all screwed on a metal baseplate. A transparent guard is placed around the coupling.

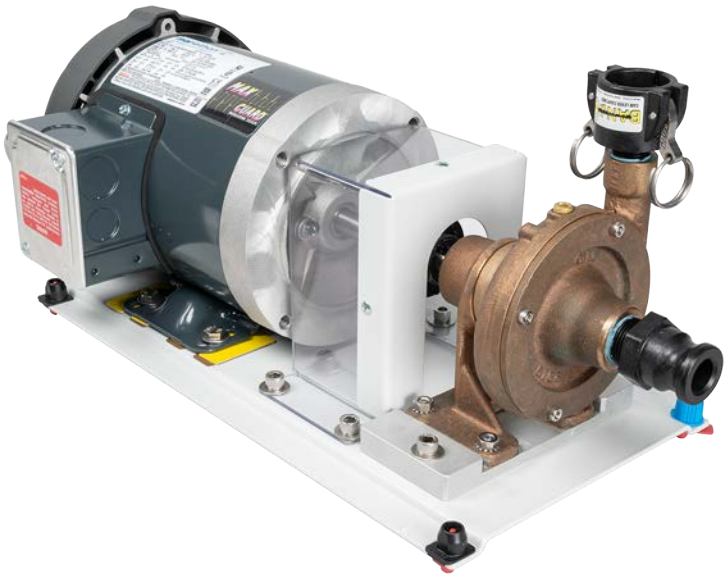

Figure 23: Long-coupled pump assembly.

Piping connections

Pipe sections connect using camlock connectors, as shown in the following figure. These connectors slip into each other and secure with two levers, creating a waterproof seal. They are easy to assemble and disassemble. The connectors lock when the levers are fully pushed to the female side.

Figure 24: Camlock connectors.

Pressure ports

You can connect meters, electronic transmitters, and other devices to the pump circuit using small hoses and two types of pressure ports: one with white caps and another with metallic caps. Both types have check valves that seal automatically when not in use. Ensure pressure lines leading to pressure instruments are filled with water for accurate readings.

Ports with white caps are easy to use: insert the pressure hose by pushing it fully into the port. To remove the hose, press the white cap while pulling the hose out.

Figure 25: First type of pressure ports.

This second type of pressure port, the one with the metallic caps, needs a male half (on the left in the next figure) that inserts into the female half (on the right), screwed into the piping. The male half has a tap with a spring that locks the connector into the pressure port.

Figure 26: Second type of pressure ports.

To attach a pressure hose to the male half of the plug, unscrew the cap (on the right in the next figure). Insert the hose all the way into the back of the plug, then screw the cap back in place.

Figure 27: Pressure hose inserted into the male half.

Electrical connections

The following figure shows the connection panel on the back of the system bench.

The system bench is connected to the electrical supply using a standard wall outlet.

Figure 28: Connection panel on the back of the system bench.

Connect the motors to the system bench using the connectors shown in the following figure. Secure them with the lever. Do not connect or disconnect when the system is powered on. The VFD powers both connectors simultaneously, allowing either pump to connect to either connector. Cover any unused connector with a protective cap.

Figure 29: Connection to the motor connector.

Transmitters (such as a flow meter) can be powered by the system bench using the 5-pin connectors shown in the following figure.

Figure 30: Transmitter 5-pin connectors.

Valves, meters and accessories

The valve on the left in the following figure is a ball valve. It is mostly used for ON-OFF applications. In the pump circuit, it is placed before the suction of the pump.

The valve in the middle is a globe valve. It is mostly used for throttle control as the flow rate it allows is proportional to its opening. In the pump circuit, it is placed after the discharge of the pump.

The valve on the right is the foot valve. It is placed inside the water tank and it acts as a check valve to prevent the pump from emptying itself when it is stopped.

Figure 31: Valves included in the learning system.

The following figure shows the measuring instruments included with the system. On the left is a rotameter for measuring water flow in the piping circuit. On the right is a pressure gauge for measuring pressure.

A rotameter uses a floater, called a bob, inside a tapered tube to measure flow rate. The pressure gauge measures pressure using a Bourdon tube, which changes shape with pressure. Details about each instrument are in dedicated sections of this course.

Figure 32: Meters included in the learning system.

Tools

Use the quick-lock tool to attach the blue quick-lock fixations to the perforated surface of the system bench. When unlocked, a small red plastic tab appears on the fixation, as shown on the right in the figure. To lock a component, turn the fixation with the quick-lock tool until its straight side is parallel to the support, as shown on the left in the figure. To unlock, turn the fixation until the red tab is visible. Note that the rotation direction may vary for different fixations.

Figure 33: Quick-lock fixations and tool.

Video on using the quick-lock tool.

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To align the coupling between the motor and the pump, the system includes a straightedge, a caliper, a set of feeler gauge, and a set of shims. Use the procedure in Learning Unit 5 to align the shafts.

Figure 34: Alignment kit.

To secure the learning system during maintenance, use a hasp, padlock, and tag. First, close the hasp around the Main switch on the system bench. Then, insert the padlock through a hole and attach the tag. Lock everything as shown in the following figure. Store the key in a safe place.

Figure 35: Lockout/tagout kit.

Figure 36: Lock-out/Tag-out device on an electrical switch.

Parts for fault insertion

The learning system includes rings of various sizes to create leaks and restrictions in the pump circuit for troubleshooting exercises. They can be identified by their thickness.

In addition to the rings, an air valve is used to inject air into the pump circuit, simulating another fault type. It connects to the piping with an included air hose through a pressure port. The other end of the valve is open to the ambient air. An arrow on the valve shows the direction of airflow.

Figure 37: Parts used to create faults.

Part description of Pump Performance

To complete the projects of this course, a few pump accessories are included with the learning system. They include a transparent pump cover that allows the user to see inside the pump during operation. It also includes a second impeller, smaller than the original, to measure the effect of the impeller size on the performance of the pump. A second mechanical seal is included as a back-up.

Figure 38: Pump accessories.

Electronic meters

For the projects of this course, an electronic flow meter is included to measure the flow rate of water in the pumping circuit. It works by measuring the induced voltage as the water flows through a magnetic field generated by the sensing device. This is possible because tap water conducts electricity. It has an LCD screen to display the value it measures in different units. It is powered by the system bench using a 5-pin connector in the back. This device replaces the rotameter.

Also included with this course, a pressure meter replaces the pressure gauge included in the Basic Pump System. It measures the pressure inside the pumping circuit using a sensor that detects the deformation of a diaphragm with the pressure. It has an LCD screen to display the value it measures in several units. It is powered by batteries.

For more details on these two components and how to use them properly, see the appropriate appendixes: Operating the electromagnetic flow meter and Operating the pressure meter.

Figure 39: Flow meter and pressure meter.

Part description of Multiple Pumps Systems

To complete the projects of this course, a second pump is included with the learning system. It is a short-coupled or C-face pump. Apart from the coupling, it has the same specifications, motor, and features as the first one.

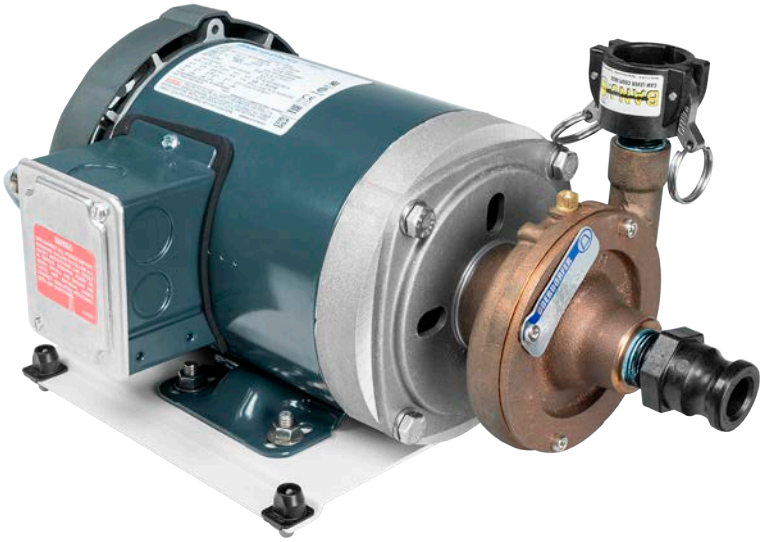

Figure 40: Short-coupled pump assembly.

To complete the exercises of this course, additional piping and hoses are included. The piping are connected in a Y configuration to connect equipment in parallel. They are connected to the pumping circuit using camlock connectors. They also have pressure ports to read pressure at different points.

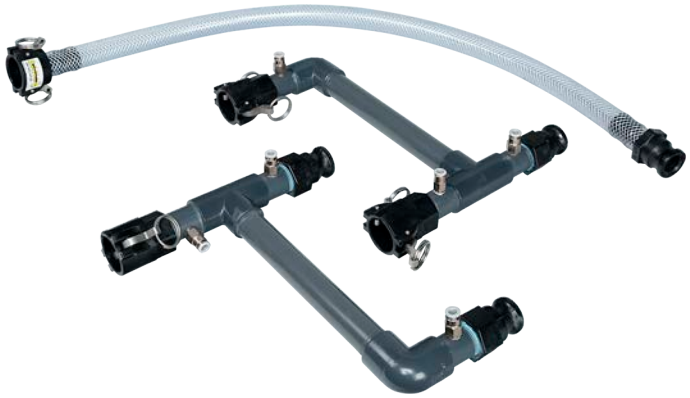

Figure 41: Y piping included.

A pair of check valves are also included. They allow water in the circuit to flow in only one direction. This direction is indicated on the check valve with an arrow on the brass body of the equipment. They are connected to the pumping circuit using camlock connectors. They also have pressure ports to read pressure before and after the check valve.

Figure 42: Check valve.

Description of the external gear pump and its accessories

External gear pump

The present course introduces the external gear pump to the main Industrial Pump Learning System. Just like the centrifugal pump, it must be coupled to the motor using the coupling, with the protective guard for protection. The step required to do that will be explained in the practice part of this course.

The external gear pump has a cover that can be removed to inspect the components inside. Grease fittings also allow the easy insertion of grease.

The external gear pump has the following specifications.

Table 13: External gear pump specifications.

Parameter	Value
Maximum speed	1750 r/min
Maximum discharge pressure	125 psi (875 kPa)
Maximum flow rate	2.8 gal US/min (10.6 l/min) at 125 psi (875 kPa)
Direction of rotation	Reversible
Sealing element	Packing seal

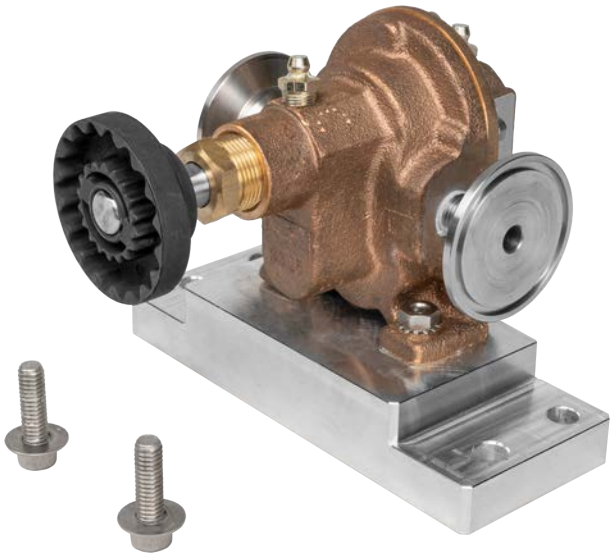

Figure 43: External gear pump with screws.

Pressure relief valve assemblies

The course also introduces two pressure relief valve assemblies. One assembly is placed downstream of the external gear pump, and the other upstream. Pressure relief valves prevent overpressure by allowing fluid to flow back to the storage tank when the pressure at the valve has reached a preset value. They act as a safety device to protect the system and its components from damage due to excessive pressure, ensuring safe and stable operation of the system.

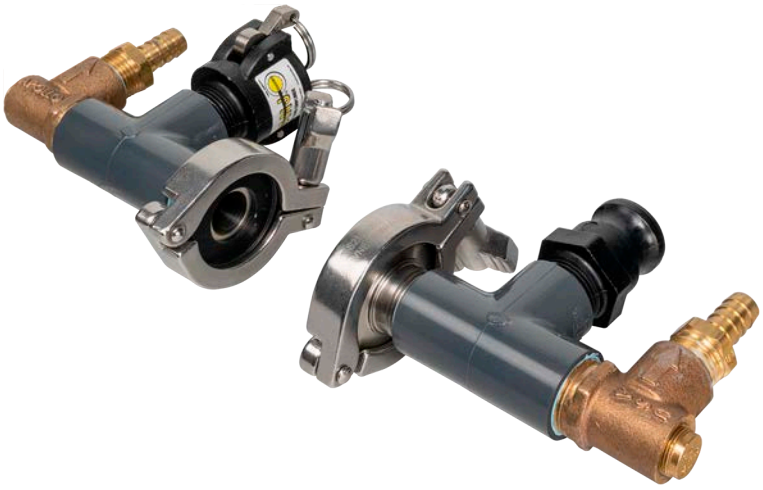

Figure 44: Pressure relief valve assemblies.

Quick-clamp fittings

The external gear pump and the pressure relief valve assemblies are equipped with quick-clamp sanitary fittings. Since the external gear pump can generate pressures higher than the maximum operating pressure of the system, 345 kPa (50 psi), the pressure relief valve assemblies must always be used with this pump. The different type of fittings prevents the learner from connecting the pump directly to the system using the standard camlock fittings.

These quick-clamp fittings allow the quick connection and disconnection of components. A clamp whose tension is controlled by a wing nut maintains the fittings firmly in place. A gasket must be inserted between the fittings to ensure the fluid-tightness of the connection.

The procedure to connect the external gear pump to a pressure relief valve assembly using the quick-clamp fittings is outlined below. See the three following figures for reference.

1. Press the fittings together, with the gasket in-between. Make sure the grooves on the gasket fit into the slots in the fittings.
2. Place the clamp on both fittings, close the clamp, and lock it using the wing nut.
3. Screw the wing nut until clamp is tightly closed.

Figure 45: Pressing the fittings together, with the gasket in-between.

Figure 46: Placing the clamp on both fittings and closing the clamp.

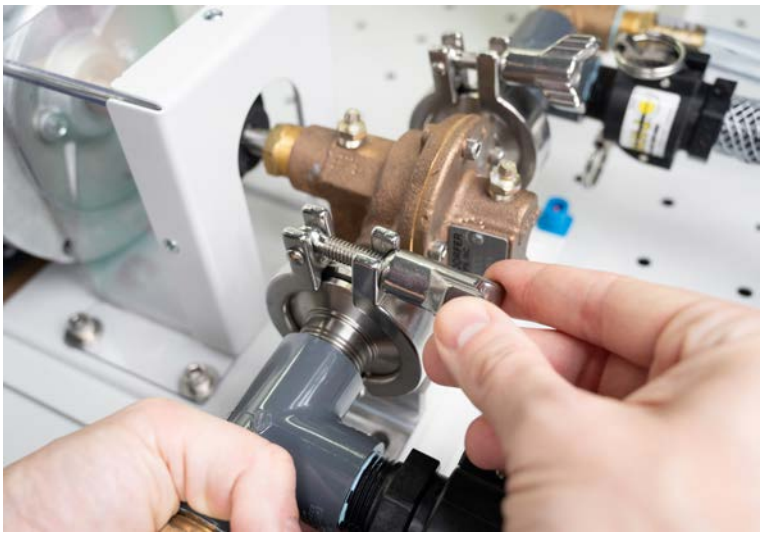

Figure 47: Locking the fittings using the wing nut.

Presentation of the flexible impeller pump

Here is the flexible impeller pump included in the learning system:

Figure 48: Flexible impeller pump on the work surface.

Figure 49: Flexible impeller pump on the work surface (back side).

The pump is coupled to the motor using a flexible coupling. The inlet and the outlet are connected to the pumping circuit using cam lock connectors.

It is possible to use this pump either in forward or reverse direction. However, with the way it is connected with cam lock connectors, it should only be used in the forward direction to prevent a pressure build-up in the foot valve.

The pump and the impeller are suited to handle fresh and salty water, as well as mild chemicals solutions. However, it is not made for harsh solvents, acids, or alkalis.

If the flexible impeller pump is not in use for prolonged periods of time, the impeller should be removed and stored properly to prevent the blades from taking a permanent set.

Table 14: Flexible impeller pump specifications.

Parameter	Value
Manufacturer	Oberdorfer
Model	201M-05
Construction	Casing: Brass Shaft: Stainless steel
Mechanical seal	Carbon and ceramic
Impeller	Neoprene, 6 blades
Operating range	0.4 to 43 L/min (0.1 to 11.3 gal/min)
Operating temperature	4 to 60°C (40 to 140°F)
Maximum suction lift	4.57 m (15 ft)
Maximum operating pressure	241 kPa (35 psi)
Maximum recommended speed	3450 r/min

Presentation of the progressive cavity pump

Here is the progressive cavity pump included in the learning system:

Figure 50: Progressive cavity pump on the work surface.

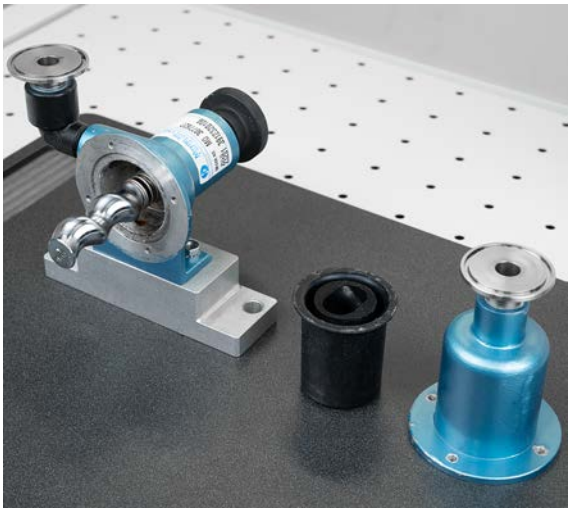

Figure 51: Insides of the progressive cavity pump.

The pump is coupled to the motor using a flexible coupling. The inlet and the outlet are connected to pressure relief valves (PRV) using flange connectors and clamps. The PRV itself is connected to the pumping circuit using cam lock connectors.

It is possible to use this pump either in forward or reverse direction. However, with the way it is connected with cam lock connectors and PRVs, it should only be used in the forward direction to prevent a pressure build-up in the foot valve.

The pump and its stator are suited to handle fresh and salty water, as well as mild chemicals solutions. However, they are not made to handle harsh solvents, acids, or alkalis.

Table 15: Progressive cavity pump specifications.

Parameter	Value
Manufacturer	MOYNO
Model	23201
Construction	Casing: Aluminum Shaft and rotor: Stainless steel Stator: Nitrile
Mechanical seal	Carbon and ceramic
Operating range	0 to 19 L/min (0. to 5 gal/min)
Operating temperature	4 to 70°C (40 to 160°F)
Maximum operating pressure	276 kPa (40 psi)
Maximum recommended speed	1750 r/min

Presentation of the pneumatic diaphragm pump

The following two figures show the pneumatic diaphragm pump in the learning system:

Figure 52: Pneumatic diaphragm pump on the work surface (front).

Figure 53: Pneumatic diaphragm pump on the work surface (back).

Contrary to the other optional pumps used with this learning system, the pneumatic diaphragm pump used in this course is not powered by an electric motor controlled by the VFD of the system bench. Instead, it uses compressed air as a power source. A pressure regulator on the valve body of the pump allows the user to adjust the output generated by the pump.

The inlet and the outlet are connected to the pumping circuit through pressure relief valves (PRV) with flange and clamps connectors. The PRV themselves are connected to the rest of the pumping circuit using cam lock connectors. The air input is connected with a standard ¼ in pressurized air push-in fitting.

This pump can only be used in forward direction, as the check valves in the pump prevent flow from going backwards. The pump and its diaphragms are suited to handle fresh and salty water, as well as mild chemicals solutions. However, it is not made for harsh solvents, acids, or alkalis.

Table 16: Pneumatic diaphragm pump specifications.

Parameter	Value
Manufacturer	ARO
Model	PD05P-AAS-PGG
Construction	Aluminum
Diaphragm	Nitrile
Fluid section	

Parameter	Value
Material pressure range	140 to 690 kPa (20 to 100 psi)
Maximum material inlet pressure	69 kPa (10 psi)
Maximum flow rate	49.2 L/min (13 gal/min)
Operating temperature	4 to 66°C (40 to 150°F)
Displacement per cycle (690 kPa, 100 psi)	0.5 L (0.04 gal)
Maximum particle size	2.4 mm (3/32 in)
Valve section	
Pressurized air requirement	71 L/min (3.1 CFM) at 630 kPa (90 psi)
Air consumption (approx.)	7.4 L/min for 1 L of material pumped (1 CFM/gal)
Air inlet range	140 to 690 kPa (20 to 100 psi)

Presentation of the peristaltic pump

Here is the peristaltic pump included in the learning system:

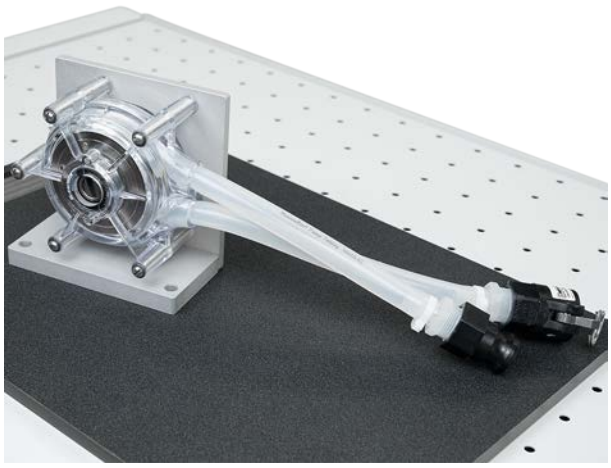

Figure 54: Peristaltic pump on the work surface.

Figure 55: Peristaltic pump without its pump cover.

⚠ CAUTION

Keep your fingers away from the accessible part of the shaft in front of the pump! Injuries may occur from fingers getting trapped in the key slot when the pump is running!

The pump is screwed to a L-shaped base, itself screwed to the baseplate of the motor-pump assembly. It uses a specific coupling hub and insert (tang boot) and its own coupling guard, slightly shorter than the one used with the other pumps.

The tubing of the pump is connected at the inlet and the outlet to the pumping circuit using cam lock connectors with the help of a pair of fittings. They can be changed easily when replacing the tubing.

It is possible to use this pump either in forward or reverse direction. However, with the way it is connected with cam lock connectors, it should only be used in the forward direction to prevent a pressure build-up in the foot valve.

The tubing is suited to handle fresh and salty water, as well as mild chemicals solutions. However, it is not made to handle harsh solvents, acids, or alkalis.

The pump is supplied with a spare tubing and spare thrust washers, which are used on the rotor assembly.

Table 17: Peristaltic pump specifications.

Parameter	Value
Manufacturer	Masterflex
Model	I/P 7019-32
Pump cover material	Polycarbonate
Rotor assembly	Construction: Cold-rolled steel Three rollers, standard fixed occlusion
Tubing	Construction: Silicone Length: 75 cm (29 in) Internal diameter: 12.2 mm (0.5 in) Thickness: 3.18 mm (0.125 in)
Operating range	0 to 13 L/min (0 to 3.4 gal/min)
Operating temperature	0 to 40°C (32 to 104°F)
Maximum discharge pressure (intermittent)	138 kPa (20 psi)
Maximum vacuum	73 kPa (10.6 psi)
Maximum recommended speed	650 r/min

Commissioning the peristaltic pump

Refer to this short video to assemble the peristaltic pump before use with the Industrial Pump Learning System.

For more details, refer to the procedure Studying the operation of a peristaltic pump.

Load the tubing and assemble a peristaltic pump.

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Presentation of the multistage vertical centrifugal pump

Here is the multistage vertical centrifugal pump included in the learning system:

Figure 56: Multistage vertical centrifugal pump on the work surface.

Figure 57: Pump with all stages removed.

This pump consists of 22 chambers stacked on the motor-pump assembly's baseplate. The motor is attached to this baseplate and connected to the pump shaft using a sintered metal split coupling. Four retainers screwed into the pump base hold the chambers together.

The pump's outlet is connected with a flange attachment and a pressure relief valve (PRV). It links to the rest of the pumping circuit using cam lock connectors. The pump's inlet is on the opposite end of the baseplate, submerged in the learning system's water tank. A nylon sleeve surrounds the pump to prevent water splashing on the user and the system.

This pump can operate in both forward and reverse directions. However, as shown in a course exercise, its performance is lower when running in reverse.

Table 18: Multistage vertical centrifugal pump specifications.

Parameter	Value
Manufacturer	Grundfos
Model	MTR 3-22/3 A-WB-A-HUUV
Pump material	Chambers and impellers: Stainless steel Pump base and head: Cast iron
Active chambers (with impeller)	3
Operating range	0 to 58 L/min (0 to 15.4 gal/min)
Operating temperature	-10 to 90°C (14 to 194°F)
Maximum discharge pressure	2496 kPa (362 psi)
Rated head	20.50 m (67.26 ft)
Maximum recommended speed	3430 r/min

Install the multistage vertical centrifugal pump on the motor

To be used with the Industrial Pump Learning System, the multistage vertical centrifugal pump must be attached to the motor and submerged in the water tank of the bench. It replaces the conventional centrifugal pump. To switch pumps, perform the following:

1. Perform a lockout/tagout procedure.

2. Remove the safety guard by unscrewing it.

3. Unscrew the motor from the base. Unscrew the coupling hub from the motor shaft. Remove the coupling insert. Be careful not to lose any screws, washers, shims, or the shaft key.

   Remove the centrifugal pump and assembly base from the perforated surface. Remove the suction support, suction assembly, ball valve and foot valve. Place all these components in their storage location.

4. Unscrew one side of the coupling guard on the multistage vertical centrifugal pump using a screwdriver.

   Loosen the screws on the coupling using a hexagonal key.

   Place the pump in the hole of the perforated surface, where the suction assembly was. Secure the pump to the perforated surface by rotating the quick-lock fixation using the quick-lock tool.

⚠ CAUTION

There is a risk of personal injury, such as intervertebral disk injury, when transporting or mounting heavy components, such as the motor and the pump, that are heavier than 15 kg. Ask for assistance if needed.

5. Place the motor on top of the black frame on the pump. The motor shaft should easily slide right in the coupling hub.

   Screw it in place with the provided screws and snap rings, using a 9/16 in key or a 9/16 in box with a ratchet. Follow a criss-cross pattern.

6. Using a screwdriver or any other prying tool, lift the coupling so that it is around the middle of its course. There should be a couple of millimeters (about 1/16 in) of play on both sides of the coupling. Screw the coupling while keeping it lifted. Tighten in a criss-cross pattern.

   Screw the coupling guard in place.

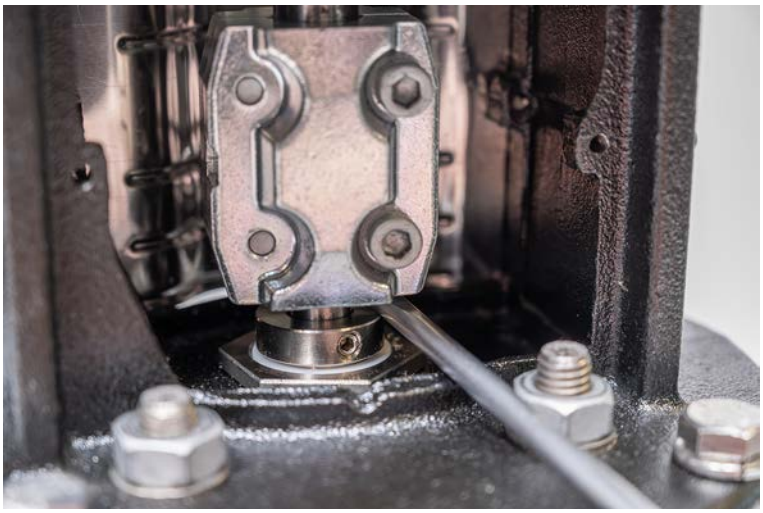

Figure 58: Lift the coupling so that the motor-shaft assembly does not drag on the motor stool.

7. Set up the pump circuit shown in the following figure.

8. Set the variable-frequency drive (VFD) for operation with a multistage vertical centrifugal pump. To do so, access parameter P0820 in the drive and set it to 1. Refer to this Learning Unit 5 if necessary.

Table 19: Parameter P0820 of the VFD.

Parameter value	Description
0	Centrifugal pump operation
1	Positive-displacement pump operation

It might seem contradictory to use the positive-displacement pump setting for a centrifugal pump, but it is not a mistake. Parameter P0820 allows the user to choose the inverter control mode. The two settings differ by how the drive calculates the voltage sent to the motor for a given frequency. Setting a value of 1 to P0820 allows the multistage vertical centrifugal pump to operate at lower speeds. Refer to the appendix Operating the variable-frequency drive for more information.

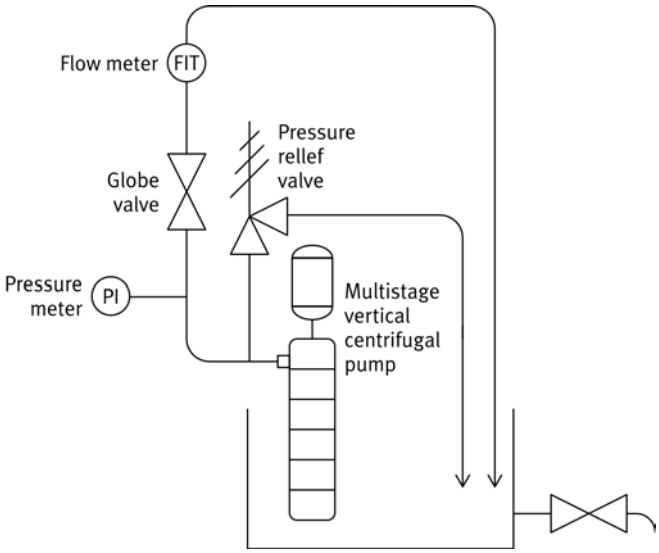

Figure 59: Multistage vertical centrifugal pump circuit diagram.

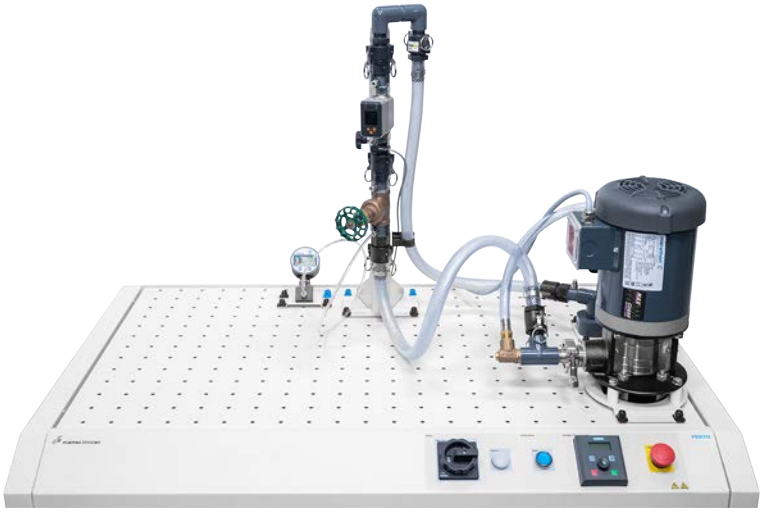

Figure 60: Setup example of the multistage vertical centrifugal pump circuit.

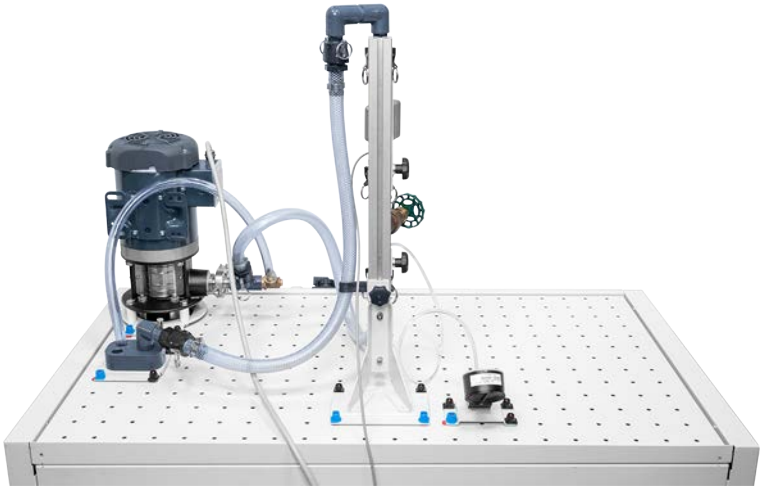

Figure 61: Back side of the multistage vertical centrifugal pump circuit.

Presentation of the vane pump

Here is the vane pump included in the learning system:

Figure 62: Vane pump attached to the motor.

The vane pump is connected to the motor using a motor adapter, that also acts as a coupling guard. The coupling between the shafts is a jaw coupling with a plastic insert.

The suction inlet and discharge outlet of the pump feature flange connectors. These are connected to the pumping circuit with fittings (not pictured here) that include a pressure relief valve (PRV) and a cam lock connector.

The pump uses 4 vanes made of carbon graphite. The vanes are pressed against the cam ring with push rods.

The pump casing is equipped with a built-in 100 mesh strainer to remove solid particles from the pumped liquid. It also includes a built-in PRV that acts as a by-pass to redirect flow from the discharge to the suction when the pressure inside the pump casing rises above the cracking pressure of the PRV. This pressure can be adjusted with a screw.

The pump can only be used in one direction. This direction is indicated with arrows on the pump casing. It is compliant with food grade requirements.

Table 20: Vane pump specifications.

Parameter	Value
Manufacturer	Fluid-O-Tech / Rotoflow
Model	PA401X
Construction	Casing: Brass Shaft and rotor: Stainless steel Vane and cam ring: Carbon graphite
Operating range	0 to 8.7 L/min (0 to 2.3 gal/min)
Operating temperature	0 to 70°C (32 to 158°F)
Maximum discharge pressure	1655 kPa (240 psi)
Maximum head	169 m (554 ft)
Maximum recommended speed	1750 r/min

Commissioning the vane pump

Refer to this short video to replace the centrifugal pump with the vane pump before use with the Industrial Pump Learning System.

For more details, refer to the procedure Studying the operation of a vane pump.

How to install the vane pump on the motor.

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Presentation of the magnetic drive centrifugal pump

Here is the magnetic drive centrifugal pump included in the learning system:

Figure 63: Magnetic drive centrifugal pump on the work surface.

Figure 64: Inner components of the magnetic drive centrifugal pump.

The body of the pump has the characteristic volute shape of centrifugal pumps. Its suction inlet and discharge outlet are connected to the pumping circuit using cam lock connectors. The pump itself is screwed to the motor with bolts. The magnet hub, screwed to the motor shaft with the help of a shaft key, transfers the power to the impeller through the pump casing.

The body of the pump and its impeller are made of rugged polypropylene, a polymer that has great chemical compatibility with a great number of products, allowing this pump to be used in many contexts. The pump is designed to be only used in the direction shown by the arrow molded into the pump casing.

Table 21: Magnetic drive centrifugal pump specifications.

Parameter	Value
Manufacturer	Finish-Thompson
Model	DB6P
Pump material	Polypropylene
Operating range	0 to 151 L/min (0 to 40 gal/min)
Operating temperature	0 to 82°C (32 to 180°F)
Maximum discharge pressure	552 kPa (80 psi)
Rated head	7.6 m (25 ft)
Maximum viscosity	150 cP
Maximum rotation speed	3450 r/min
Magnet	Neodymium, 6 poles

Commissioning the magnetic drive centrifugal pump

Refer to this short video to replace the conventional centrifugal pump with the magnetic drive centrifugal pump before use with the Industrial Pump Learning System.

For more details, refer to the procedure Studying the operation of a magnetic drive centrifugal pump.

How to install the magnetic drive centrifugal pump on the motor.

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Indications of conformity

The following EU directives are relevant for the CE marking of the equipment:

- Low-Voltage Directive
    - The Low-Voltage Directive requires that products do not cause electrical hazards.
- Electromagnetic Compatibility (EMC) Directive
    - The EMC Directive requires that electric devices must only influence one another to a limited extent.
- Restriction of the Use of Certain Hazardous Substances (RoHS) Directive
    - The RoHS Directive requires a limit to hazardous substances such as lead, mercury, cadmium, or chrome.

Declarations of conformity (CE or UKCA) for the equipment are available on request.

Electromagnetic compatibility (EMC)

The following table outlines international electromagnetic compatibility (EMC) compliance requirements, specifying applicable standards, equipment classifications, and usage limitations.

Table 22: Overview of electromagnetic compatibility (EMC) compliance.

International	EN IEC 61326-1: Basic Electromagnetic Environment CISPR 11: The equipment in this user guide is Group 1 only, Class A ● Group 1: Equipment covered by this standard that is not classified as Group 2. Group 2: Industrial, scientific, and medical radio-frequency (ISM RF) equipment that intentionally generates or uses radio-frequency energy (9 kHz to 400 GHz), locally applied via electromagnetic radiation, inductive or capacitive coupling, for purposes such as material treatment, inspection, analysis, or energy transfer. ● Class A: Equipment is suitable for use in all establishments other than domestic and those directly connected to a low-voltage power supply network that supplies buildings used for domestic purposes. There may be potential difficulties in ensuring electromagnetic compatibility in other environments due to conducted and radiated disturbances. ● Caution: This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.

Equipment Maintenance

The equipment is designed to ensure user safety, reliability, and effective learning outcomes. To maintain safety and performance, it is important to keep the equipment in good condition.

The learning system needs regular maintenance. Students will perform some tasks as part of their training, while qualified personnel must handle other periodic maintenance.

Since trainees may not yet detect issues, a technician or instructor should inspect the system before and after each use.

Replace defective or missing components immediately. Contact our service department for replacement parts and instructions.

⚠ CAUTION

- Instructors and laboratory personnel must communicate these directions and guidelines to students, as they are essential for maintaining the equipment's safety and functionality.
- Do not operate the equipment with missing or damaged parts.

General maintenance

The equipment does not require any particular maintenance. However, it is very important to perform a visual inspection of the equipment before each laboratory exercise. If a piece of equipment appears damaged or shows wear, it must be replaced to ensure user safety and prevent further damage to the equipment.

There are no user serviceable parts inside the equipment, other than certain parts that may need to be replaced, such as fuses, button cells, batteries, etc. Opening or removing the equipment housing to replace parts may expose you to dangerous voltages. Do not try to open the equipment housing to replace parts. Have a qualified technician replace parts in the equipment.

General recommendations

When the pump is in operation, do not keep any of the valves (suction and discharge) closed for more than one minute. This can put stress on the pump and cause damage. Similarly, it is not recommended to run the pump dry or when it is deprimed for more than a few seconds.

Fill the tank using regular tap water. Use a tape measure to look at the level inside the tank. Get the water to reach about 28 cm (11 in) from the perforated surface. Do not use anti-microbial additives.

Change the water in the tank frequently to avoid mold and microbial growth. It is recommended to change the water every three months, or more often if required. Clean the inside of the tank with a cloth and soft detergent if required. Rinse off any trace of detergent before fulling back the tank. Drain the tank when the learning system is not in use for long periods of time.

Drain the water tank

To drain the tank, the level of water needs to be above the drain valve.

1. Remove the suction and foot valve assembly from inside the tank. Do the same with the discharge end of the pumping circuit.
2. Screw a hose to the drain valve. Place the other end in a water drain and secure the hose to the floor. If you have access to a large floor drain, you can place the learning system over it to empty the tank.
3. Open the drain valve all the way. Wait until most of the water has drained before the next step.
4. Unscrew the two thumbscrews holding the drip tray in place in front of the tank. Pull out the drip tray. Pull the tank out of its place and tip it to drain the remaining water. Now is the time to clean the tank interior if needed.
5. Put the tank back in place. Put the drip tray in place and screw it in. Close the drain valve.

Cleaning

To clean the front panel(s) and housing(s) of the equipment, use a soft cloth and a mild solution of detergent and water. It is important not to apply the solution directly onto the surface of the equipment. Instead, apply the solution onto the soft cloth.

NOTICE

Unless specifically stated otherwise, do not use abrasive substances or solvents to clean any part of the equipment.

Equipment modification

Do not modify the equipment without prior written permission of Festo Didactic. The equipment was designed in accordance with various regulations (safety, electromagnetic compatibility, etc.). Modifications could have undesired consequences on product integrity and safety.

The use or installation of spare parts by unqualified persons, as well as any repair or modifications not complying with the product's original specifications and manufacturing methods, can cause material damage, serious injury, or even death. It may also void any warranty or product approval.

Equipment disposal

Do not discard the equipment with normal waste: it contains electrical and electronic components. A specialist must dismantle the product. Each component must be recycled or disposed of according to your local legislation.

It is the owner's responsibility to make provisions for the equipment recycling and safe disposal.

Waste from Electrical and Electronic Equipment (WEEE) directive:

- In accordance with European regulations, used electrical and electronics devices cannot be disposed of in unsorted municipal waste. The symbol of the waste bin on wheels indicates the necessity for separate collection. For environmental protection, make sure the equipment is disposed of in the waste sorting processes designed for this purpose. DIRECTIVE 2012/19/EU of the EUROPEAN PARLIAMENT AND OF the COUNCIL of 4 July 2012 on waste electrical and electronic equipment (WEEE).

The presence of this symbol on the equipment indicates the necessity of separate collection.

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