Three-Phase Separator Learning System

Process Automation

User Guide

Festo Didactic
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Document Preliminaries

About this document

The present user guide covers the installation, operation, and components of the Three-Phase Separator Learning System. It is divided into several units and covers the following topics:

- System Technical Specifications. This unit lists the main specifications of the Three-Phase Separator Learning System.
- Quick-Start Guide. This unit explains how to prepare and start the separator at the beginning of a laboratory session.
- Basic Operation. This unit lists and presents the main components of the learning system. It also explains how to use the learning system in normal operating conditions.
- HMI and Fault Switches. This unit presents the Human-Machine Interface (HMI) of the instrumentation package and some of the menus its software contains. It also presents the fault switches and fault valves of the system, their use and their location.
- The next four units concern the instrumentation of the Three-Phase Separator Learning System: the flow instrumentation (rotameter, turbine, differential-pressure, electromagnetic, Coriolis), the level instrumentation (displacer, float, tuning fork, multiparameter radar), the pressure instrumentation, and the temperature instrumentation.
- Maintenance and Inspection. This unit deals with the upkeep of the Three-Phase Separator Learning System. It also lists the verifications that must be performed to ensure that your learning system is in adequate condition before use.
- The Shutdown and Purge guide. This unit contains a procedure to turn off the Three-Phase Separator Learning System properly when it is not in use. It also contains a procedure to purge the vessel of the learning system when it is not used for a longer time.

The total time required to perform this course is: 2.6 hour(s)

Core documentation

This document contains the information required to set up, commission, and carry out maintenance on your equipment. However, for specific instructions or information, you may have to refer to the other documents listed in the following table, which form the core documentation for this product.

Table 1: Core documentation.

Title	Type	Part number
Three-Phase Separator – Basic Control	Instructor manual (A4 format)	8120527/8120528
	Instructor manual (Letter format)	8097886/8097887
	Student manual (A4 format)	8120529/8120530
	Student manual (Letter format)	8097888/8097889
Three-Phase Separator – Instrumentation	Instructor manual (A4 format)	8120553/8120554
	Instructor manual (Letter format)	8099616/8099617
	Student manual (A4 format)	8120555/8120556
	Student manual (Letter format)	8099619/8099620
Three-Phase Separator	User guide	8167643/8167644

Tips, feedback, and suggestions

We invite readers to send us their tips, feedback, and suggestions for improving the course.

Please send these to: services.didactic@festo.com

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The authors and Festo Didactic look forward to your comments.

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.

Symbol	Description
	**WARNING** indicates a hazard with a medium level of risk, which, if not avoided, could result in death or serious injury.
	**CAUTION** indicates a hazard with a low level of risk, which, if not avoided, could result in minor or moderate injury.
	**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.

Symbol	Description
	Caution, chain drive entanglement hazard.
	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.

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

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 equipment 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.

For Your Safety

Important information

Fundamental prerequisites for safe use and trouble-free operation of the equipment include knowledge of basic safety precautions and safety regulations. This document includes important instructions for safe use of the equipment.

In particular, the safety precautions must be adhered to by all persons who work with the equipment. In addition, all pertinent accident prevention rules and regulations, which are applicable at the respective place of use, must be adhered to.

Obligations of the operating company

The operating company only permits those who meet the following qualification to work with the equipment:

- Persons that are familiar with the basic regulations regarding work safety and accident prevention, and have been trained in the use of the equipment.
- Persons that have read and understood the chapter concerning safety and the warnings in this manual.

Personnel should be tested at regular intervals for safety-conscious work habits.

Obligations of the trainees

All persons who have been entrusted to work with the equipment must complete the following steps before beginning work.

- Read the chapter concerning safety and the warnings in this manual.
- Familiarize themselves with the basic regulation regarding work safety and accident prevention.

General safety recommendations when using the system

In addition to the symbols listed above, the following warnings must always be taken into consideration when performing manipulations using the Three-Phase Separator Training System:

⚠ WARNING

- Before operating the equipment, make sure that the secondary protective earthing conductor is properly connected to an external earthed part (this connection must be performed by a professional!) Also, make sure that the insulation of this conductor is not damaged or removed.
- The equipment may produce high leakage currents (≥10 mA). Correct installation of the secondary protective earth conductor by a professional is mandatory! Incorrectly connected or missing secondary protective earth conductor may lead to severe injury or death.
- Before making or modifying any connections on the equipment, always make sure that the main power switch is turned off.
- Be sure to establish a protective earthing connection before connecting the power cord. The protective earthing connection must have a cross-section of at least 4.0 mm², according to EN60204-1. The green-yellow protective conductor supplied with the system bench fulfills this requirement.
- Do not use cables and connectors from other manufacturers. Always use the cables provided with the equipment to make all connections.

⚠ WARNING

Qualified supervision is necessary at all times when the Three-Phase Separator Training System is used to perform manipulations of any sort.

⚠ WARNING

Always power off any equipment after performing manipulations. The Three-Phase Separator Training System must never be left powered on when the equipment setup is unattended.

⚠ WARNING

This system is operated under pressure. Always release the pressure when it is not in use.

⚠ WARNING

The separator contains oil and water. Beware of spills as they both can be a slipping hazard.

⚠ CAUTION

The equipment may produce high sound pressure levels (≥80 dBA) in certain operating conditions which may cause discomfort, hearing impairment, or headaches. Wear protective earpieces when operating the system in such conditions.

Table 2: Safety instructions and equipment of the learning system.

Safety aspect	Description
Personal protective equipment	Wearing appropriate clothes and protective equipment is essential to limit the risk of injury when using the learning system. It is important to have in mind that protective equipment is not a substitute for good work practices. Always wear safety glasses and protective shoes. Note that many injuries result from wearing improper or poorly fitting protective equipment. When filling the system, it is recommended to wear a lab coat to protect your clothing from oil spills.
Chemicals	Water, mineral oil and food coloring are the chemicals provided with the learning system. Though not dangerous, these products should be handled with care to avoid spills and thus the creation of falling hazards. Do not drink the liquids provided with the learning system. The mineral oil supplied is chosen because of its physical properties, like its viscosity and density.
Spill kit	A spill kit is necessary in settings where hazardous spills are possible. It must contain absorbent material, cleaners and barriers to limit the spill. Chemicals might be needed if an immediate treatment of the spill is necessary. For example, a neutralizing agent is necessary in case of the spill of an acid. A spill kit must be assembled accordingly to the risk of the possible spills around. With the learning system, at least an absorbent should be available in case of spills. An oily floor becomes extremely slippery and it is a safety hazard. An absorbent working both for water and oil should be kept close as both liquids have chances of spills. No spills should be left unattended to protect possible passersby. Industrial products are widely available to absorb spills, however cat litter or sand can do the trick.

Safety aspect	Description
Material handling	The learning system is heavy. Therefore, it should remain in its place unless otherwise specified. Only authorized individuals should be allowed to move the system. To avoid injuries, ask for assistance when it is needed to move it. Wearing safety shoes is recommended when moving the system.

Lockout/Tagout procedure

Before doing maintenance on the learning system, always perform a lockout/tagout procedure. A hasp, a padlock, and a tag are provided for that purpose, as the following figure shows.

To perform the lockout/tagout procedure, close the two ends of the hasp on the main power switch of the system. Pass the padlock through one of the holes and add the identifying tag. Lock the assembly in place. Each user of the equipment must install their own padlock/hasp. Keep the key at a secure location.

Figure 1: Lockout/tagout hasp, lock, and tag.

System Technical Specifications

The Three-Phase Separator Training System is available in different versions to accommodate the various ac power voltage and frequency combinations used worldwide. The system requirements for each available version are indicated below.

Table 3: 120 V, 50/60 Hz version.

System requirements	
Current	12 A
Short circuit current rating (SCCR)	5 kA
Air supply	113 L/min at 6.2 bar 4 scfm at 90 psi
Water	114 L 30 gal
Mineral oil (included in the system)	57 L 15 gal

Table 4: 230 V, 50/60 Hz version.

System requirements	
Current	7 A
Short circuit current rating (SCCR)	5 kA
Air supply	113 L/min at 6.2 bar 4 scfm at 90 psi
Water	114 L 30 gal
Mineral oil (included in the system)	57 L 15 gal

Table 5: Other technical specifications.

Other specifications	
Maximum operating pressure	0.69 bar 10 psi
Operating pressure	0 to 0.48 bar 0 to 7 psi
Vessel volume	120 L 32 gal
Dry weight	385 kg 850 lbs
Total weight	549 kg 1210 lbs
Maximum flowrates	12 L/min 3 gpm

Environmental requirements

The equipment is designed to be installed 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.

Make sure that the location where you want to install the equipment meets the environmental requirements listed above, and then follow the directives given in the next sections to safely install and use the equipment.

Indications of conformity

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

- Machine Directive
  - The Machine Directive requires that the product do not cause mechanical or 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.

The compliance document related to this system is attached to the present user guide.

Festo Didactic CE declaration of conformity.

Quick-Start Guide

The present unit provides a quick-start procedure to fill and prepare the Three-Phase Separator Training System at the beginning of a laboratory session.

NOTICE

The verifications listed in the Inspection checklist of the present user guide must have been performed to ensure that the Three-Phase Separator Training System is properly set and in good working condition. The system must be inspected for damage and all valves must be set at their normal position. Failure to do so could result in damage to the equipment.

Figure 2: Three-Phase Separator Learning System.

1. Using a funnel, pour 57 L (15 gal) of the provided mineral oil into the oil tank. This is the small tank on your left when looking at the front of the system.

2. Using a funnel, pour 114 L (30 gal) of tap water into the water tank. This is the large tank on your right when looking at the front of the system. Add 10 drops of blue dye into the water (optional but helps to clearly see the level of water inside the vessel).

Regular tap water is unlikely to cause any problem on the operation of the learning system. However, very hard water can cause a mineral crust to form on some components.

3. Wipe any spill on the system or the floor to avoid slips.

4. Connect the separator to a source of pressurized air (see System Technical Specifications). Connect the electrical cabinet to a wall outlet.

5. Start the Three-Phase Separator Learning System by turning the switch on the Pumps Control Unit. Wait a few seconds for the HMI and different meters to boot (if your system is equipped with these instruments).

Your learning system should be ready for use.

- To start the separation process, follow the Basic operation procedure.
- It is very likely you will need to prime the oil and water pumps to get the system going. Unprimed centrifugal pumps cannot create a flow, so the vessel cannot fill itself. To prime a pump, follow the procedure in the next section.
- To complete the configuration of the different meters, look up the information provided in the following sections of this document, the procedures included in the "Three-Phase Separator – Instrumentation" course, and the manufacturer's documentation.

Figure 3: Pumps Control Unit.

Priming a pump (if required)

A centrifugal pump that is not primed cannot perform its duty. The gas filling up the casing (in this case, air) will get compressed by the movement of the impeller and restrict liquid from entering the casing. Centrifugal pumps rely on a pressure differential and the incompressibility of liquids to create a flow.

1. If you need to prime a pump, first make sure there is no pressure inside the vessel. To clear pressure from the vessel, open one of the bypass hand valves on the salelines until the reading on the pressure gauge reaches zero. Do not feed air into the system yet.

2. Turn the knob of the rotameter to slightly open the inlet valve of the appropriate liquid (about a quarter of a turn).

3. Set the drive of the pump at 40 Hz. Press the green button on the setpad to start the pump.

4. Turn it off using the red button on the setpad and on again until the pump is primed and a flow is achieved. Set the input flowrate to the required value.

5. Repeat the same process on the second pump if needed. Both pumps are now functional.

Basic Operation

This unit introduces many of the components of the Three-Phase Separator Learning System. This includes the ones needed for the basic operation of the separation process, as well as the safety devices of the separator. The measurement instrumentation of the system is presented in more details later in this document, each in their own section.

It also provides a basic operation procedure to use the learning system in a normal laboratory session. No specific experimentation is performed on the learning system here, follow the procedures included in the Basic Control and Instrumentation courses for more details.

NOTICE

The verifications listed in the Inspection checklist of the present user guide must have been performed to ensure that the Three-Phase Separator Training System is properly set and in good working condition. Failure to do so could result in damage to the equipment.

Presentation of the system components

Component identification

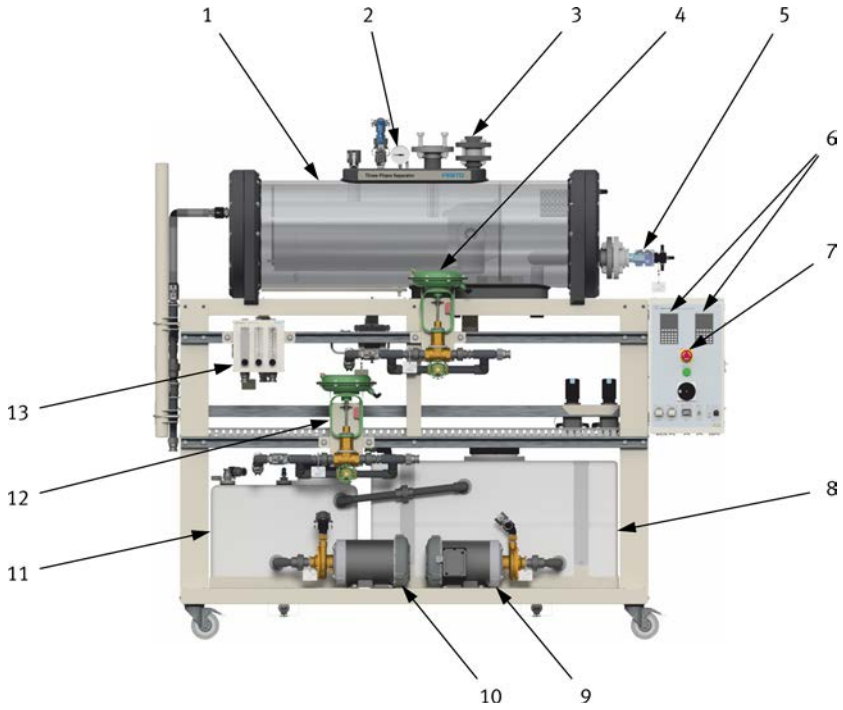

Figure 4: Front of the separator.

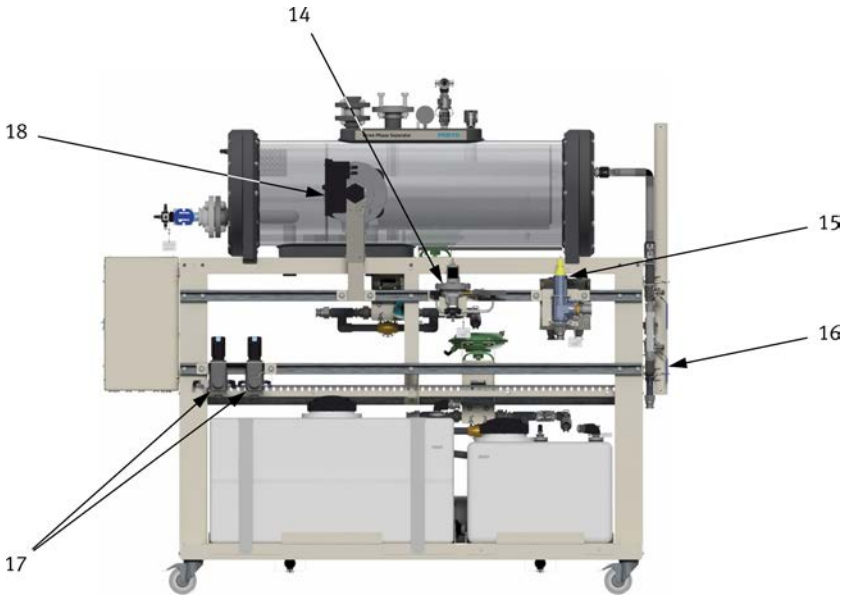

Figure 5: Back of the separator.

Table 6: Identification of the main components.

Number in figure	Component
1	Vessel
2	Pressure gauge
6	Pumps setpads
8	Water tank
9	Water pump
10	Oil pump
11	Oil tank
13	Input rotameters
14	Back pressure regulator
15	Pressure safety valve
16	Inline mixer

Table 7: Identification of the safety components.

Number in figure	Component
3	Burst disc
7	Emergency stop

Table 8: Identification of the pneumatic components.

Number in figure	Component
4	Water level control valve
5	Pneumatic float level controller
12	Oil level control valve
17	Pressure regulators
18	Pneumatic displacer level controller

Component description

Table 9: Description of some components of the learning system.

Component	Description and characteristics
Vessel	The vessel of the Three-Phase Separator Learning System is made of clear acrylic as it allows the user to see through the wall of the vessel. It holds a volume of 121 L (32 gal) and can withstand a pressure of 200 kPa (30 psi), although safety devices are present to prevent the system from reaching this pressure. Its maximum operating pressure is 69 kPa (10 psi).
Coalescing plates	The vessel contains a set of five corrugated plates to help separation of oil and water. They reduce the agitation to a gentle level that increases the number of collisions between droplets and helps their coalescence into larger droplets. They also increase the retention time inside the vessel.
Pumps	The Three-Phase Separator Learning System includes two centrifugal pumps, one for oil and one for water. They are not self-priming. Each has a power of 1 hp. Using a variable-frequency drive (located in the pump control unit), they can produce a flow of 0-12 L/min (0-3.2 gpm) at 100 kPa (14.5 psig).
Inline mixer	The stability of an emulsion is greatly related to the degree of agitation provided. To simulate a system where the fluid is vigorously mixed, an inline mixer is provided with the Three-Phase Separator Learning System. It contains baffles that divert the flow and cause an important amount of agitation. A functioning inline mixer assures a thorough mixing of the fluids before entering the vessel.

Component	Description and characteristics
Tanks	The system is supplied with two liquid tanks. A smaller 57 L (15 gal) for oil and a larger 114 L (30 gal) for water. An overflow connects the two. This allows the oil that is carried with the water when emptying the vessel to flow back into the oil tank.
Outlets	The oil and water outlets of the system, both located on the bottom of the vessel, are equipped with vortex breakers. Like their name suggests, they are used to prevent the formation of a vortex when liquids are flowing out of the vessel. Without it, gas could escape with the liquid into the sale lines. There is also a demister on the gas outlet. It is used to prevent mist and vapor from leaving the vessel with the gas. It is made of wire mesh to maximize contact surface.
Burst disc	On the Three-Phase Separator Learning System, the burst disc is designed to resist up to 68 kPa (10 psi). It is made of resin-impregnated graphite.
Pressure safety valve	A pressure safety valve relieves the pressure inside the vessel when it reaches 48 kPa (7 psi). The normal operating pressure of the vessel is around 20-28 kPa (3-4 psi). It is the blue and yellow device located right next to the inline mixer.

Figure 6: Inline mixer and pressure safety valve.

Figure 7: Coalescing plate assembly of the learning system.

Pump control unit

The first contact between the learning system and its user happens on the pump control unit, shown in the following figure. It houses the setpads for the pumps operation, the emergency stop button, the RESET button, the power switch for the system, and different connectors.

Figure 8: Pump control unit.

The setpads (T1 and T2) are used to control the pumps. The left one controls the oil pump while the right one controls the water pump. The pumps are started by giving the setpad a frequency instruction. Both pumps are designed to work at 40 Hz. To start a pump, enter the frequency setpoint with the numeric keys and validate with the "↵" key. The drive starts when pressing the green "|" key, and it stops when pressing the red "O" key. The "←" key allows the user to correct the entered value before validation. The other keys are not used in this course.

NOTICE
Do not press the reverse drive key (on the upper left, with two curved arrows). Allowing the drives to rotate in reverse will cause damage to the pumps.

The emergency stop button (S1) can be used in an emergency situation. It does not solve problems automatically; it only shuts down the pumps. Further action needs to be taken by the user to fix the situation. It is activated by pressing on it and turning it to the left to reset it.

The green light indicator (P1) shows to the user if the system is powered.

The rotating switch (Q1) turns the system on or off.

The RESET button is used to restart the system after an emergency stop. If a user stops the system using the emergency stop button, he must perform two actions to restart the system: first, deactivate the emergency stop, and then press the RESET button.

Swivel casters

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

Figure 9: Press on the foot brake to lock the caster.

Figure 10: Caster in the locked condition.

List of part numbers

The following table lists the components included in the Three-Phase Separator Learning System.

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.

Table 10: Components included in the Three-Phase Separator Learning System.

Part number	Equipment
8093513	Water Pump Assembly
8093516	Oil Pump Assembly
8106554	Turbine Flow Transmitter
582410	Differential-Pressure Transmitter (low range)
8093631	Pressure Safety Valve
8092031	Vibrating Fork Level Switch (long)
588333	Pressure Transmitter
8092029	HMI Touch Screen
8098928	Multiparameter Guided-Radar Level Transmitter
8096149	Orifice Plate
8093322	Pneumatic Control Valve
8093315	Back Pressure Regulator
8093414	Pneumatic Float Level Controller

The following table lists tools and spare parts used with the Three-Phase Separator Learning System.

Table 11: Tools and spare parts used with the Three-Phase Separator Learning System.

Part number	Equipment
8101331	Mineral Oil, 5 gal
793694	Socket Wrench Boxset
785285	Funnel
766986	Tyraps, black

Part number	Equipment
782880	Adjustable Wrench, 10"
8107626	6-Point Standard Socket, 3/8", 24mm
789487	Hex Key, 4 mm
780926	Phillips Screwdriver
8100986	Ring Hose Coupling, ¾"
773738	Shearcutter
8110598	Blue Dye
766932	Plastic Tubing, ¼"
8093633	Plastic Tubing, 3/8"
8107610	Elbow Hose Connector
8101326	Hose, 72 cm
8101327	Hose, 115 cm
8101322	Hose, 35 cm
8101323	Hose, 40.5 cm

The Three-Phase Separator Learning System is available in two versions:

- 8094286: 120 V version
- 8094287: 230 V version

Basic operation

Figure 11: Three-Phase Separator Learning System with Instrumentation.

Once the Quick-start procedure has been completed and the learning system has been inspected, it is ready to be operated for oil-water-gas separation.

1. Start the Three-Phase Separator Learning System by turning the switch on the pump control unit. Wait a few seconds for the HMI and different meters to boot (if your system is equipped with these instruments).

2. Set the pumps at 40 Hz on each setpad of the pump control unit. Press the green button of each setpad to start the pumps. If the pumps are not primed, no liquid will flow out of the pumps; nothing but noise will happen. Refer to the Quick-start guide of the present user guide if this happens.

3. Immediately after starting the pumps, set the flow rates on the rotameters at 4 L/min (1 GPM) for both water and oil, and 30 SLPM (1 SCFM) of air.

NOTICE
Do not let the pumps run with closed valves; this could cause overheating and damage the equipment.

4. It is usual for the air rotameter to fill with small quantities of oil and water. It is best to remove the liquid to assure a higher flow rate accuracy. If no liquid is present, skip this step. Stop the oil and water pumps by pressing the red button on each setpad. Set the air flow rate at 90 SLPM (3 SCFM) for about 30 seconds. Bring back the air flow rate to 60 SLPM (2 SCFM) and start back the pumps.

5. Wait for the flow rate reading to stabilize. At first, water and oil may be mixed in the input line, but this should not last more than one minute, and it has no influence on the operation of the system.

6. A mixture of water and oil should flow from the rotameters board into the left side of the vessel. Is this what you see?

☐ Yes ☐ No

Yes

7. The pressure should go up and stabilize at around 20 kPa (3 psig). Is this what you see?

☐ Yes ☐ No

Yes

If not, verify the setting on the pressure regulators.

8. The level of liquid slowly rises up inside the vessel. The water and the oil start to separate more efficiently when reaching the coalescing plates. Take a look all around the system to check for any leaks.

9. Upon reaching the level of the weir plate, the oil should start dripping down into the oil bucket. Is this what you see?

☐ Yes ☐ No

Yes

If the level does not reach the weir plate, this means that liquid escapes the vessel through the water sale line. Check the bypass of the water pneumatic valve. If the bypass is closed, the pneumatic valve may be opened at the wrong setting. Adjust the displacer level controller so the valve opens at the right level.

10. Keep on feeding into the vessel. At some point, the level of water inside the vessel will reach the setpoint of the displacer. This should trigger the level controller to open the control valve on the water sale line. Water should start flowing down into the tank. Is this what you see?

☐ Yes ☐ No

Yes

Once the water level has gone down below a certain point, the displacer should close the control valve and the flow should stop. Is this what you see?

☐ Yes ☐ No

Yes

If this is not what happens, check the air supply to the displacer level controller or adjust its settings.

11. In a similar way, the oil float in the oil output section should trigger the opening of the oil control valve once its setpoint has been reached. Then, the valve should close automatically when the level reaches below a certain point. Is this what you see?

☐ Yes ☐ No

Yes

If this is not what happens, check the air supply to the float level controller.

The Three-Phase Separator Learning System is now filled up and performing oil-water-gas separation. It will continue on its own as long as material is fed into the vessel. This procedure is now complete.

If the learning system is not used immediately, it should be shut down. Set all the intake flow rates to zero and shut down the pumps. Follow the Shutdown procedure of the present user guide for all the necessary steps.

HMI and Fault Switches

HMI stands for "Human-Machine Interface". It designates any device that allows communication between a machine and its user. The instrumentation of the Three-Phase Separator Training System includes a touchscreen HMI (Model 8092029).

Fault switches are an important feature of the learning system. They are used in the troubleshooting exercises to simulate defects on the equipment.

Human-machine interface

The instrumentation of the learning system includes a 25.4 cm (10 in) touchscreen board with a custom software. Its purpose is to give information about the separation process to the user. This includes:

- Flow rates
- Levels
- Pressure
- Temperature
- Trends of these measurements
- Alarms

The instruments are symbolized as boxes around the vessel. The readings, alarms, and warning symbols of the instruments are shown in the boxes. Instruments are identified by their P&ID identification number.

Figure 12: Touchscreen board.

Presentation of the general menus

The main screen of the HMI shows an overview of all the instruments of the learning system.

Table 12: List of measuring instruments.

Instrument number	Description
LS101	High-level vibration switch
LS102	Low-level vibration switch (water)
LS103	Low-level vibration switch (oil)
LIT101	Guided-radar level meter
TIT101	Temperature meter
PIT101	Pressure meter
FIT201	Water output flowmeter
FIT301	Oil output flowmeter
FIT401	Gas output flowmeter

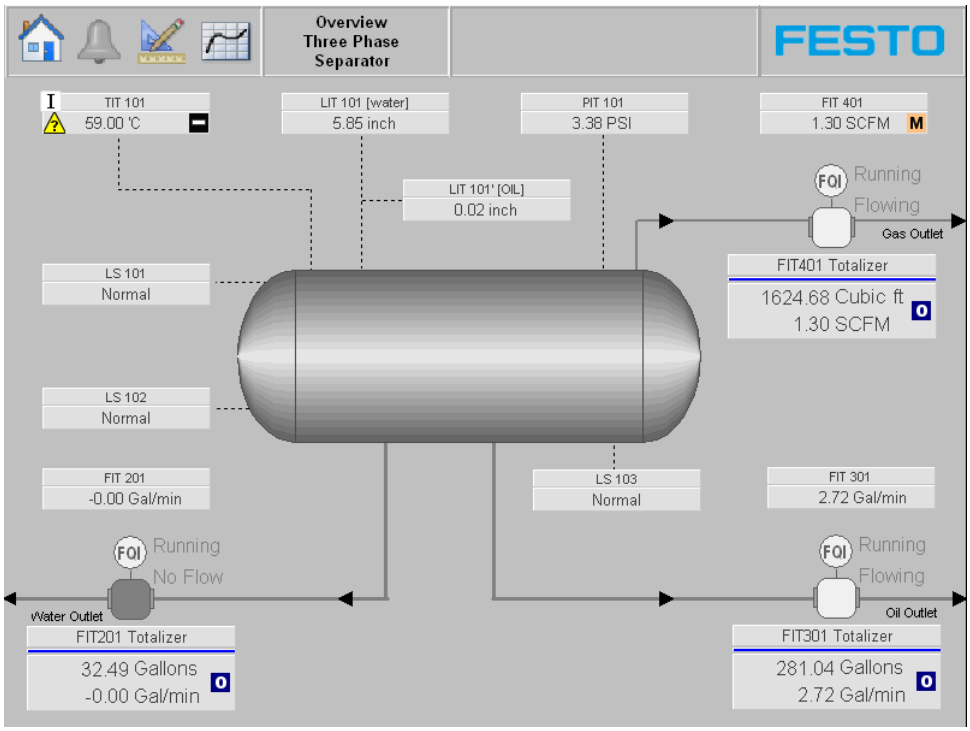

Figure 13: Main screen.

The bell icon takes the user to the alarm menu. There, it is possible to see the active alarms (which are highlighted) and a logbook of past alarms. Alarms are acknowledged using the "ack" buttons.

The settings icon takes the user to the settings menu, where it is possible to switch between units, set the meters linked to some of the inputs and show the P&ID diagram instead of the instrumentation.

The trends icon shows the user visual trends of the measurements made by the different instruments.

Click on the home icon to return to the main screen.

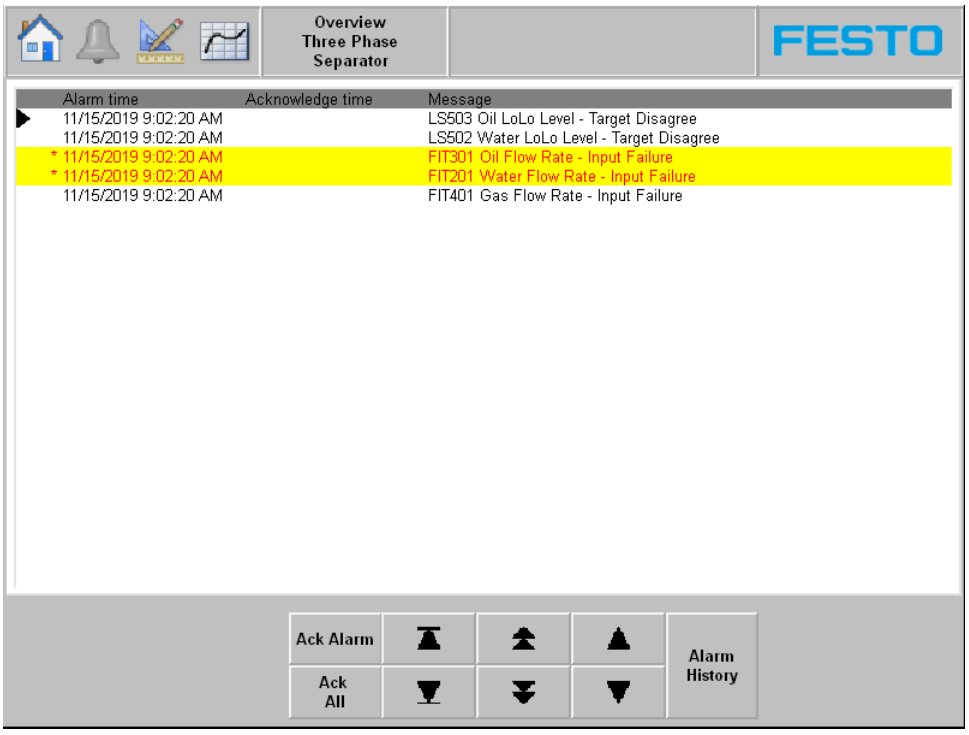

Figure 14: Alarm menu.

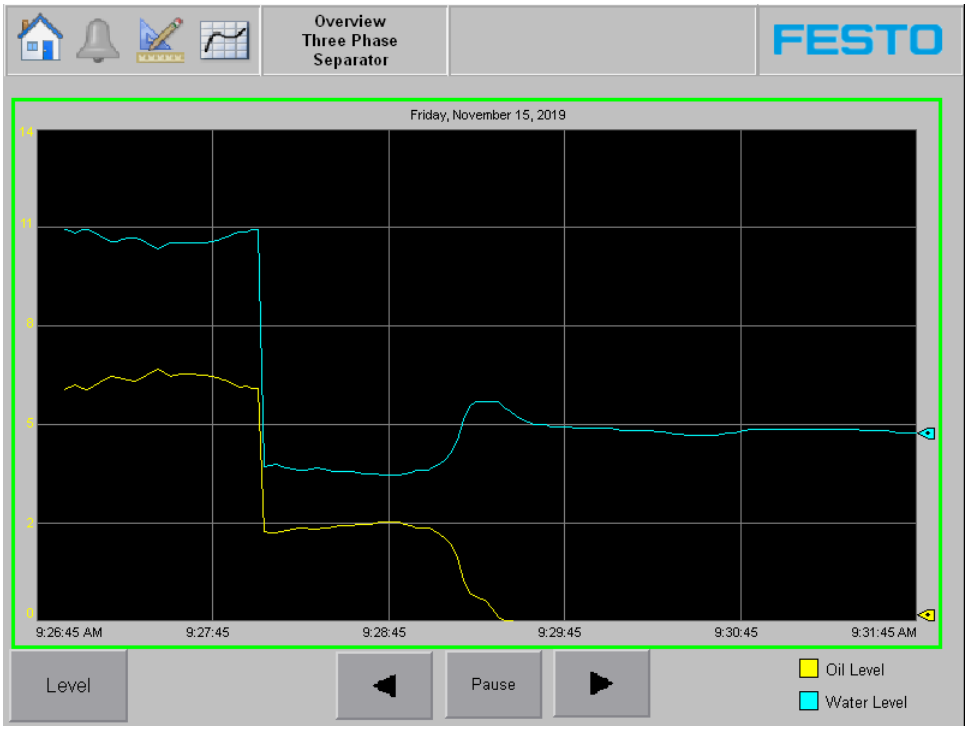

Figure 15: Trend recorder.

Presentation of the instruments menus

Pressing on one of the instrument boxes in the main screen opens a window giving additional information on this particular instrument or parameter. The following figure shows the window associated with the water level inside the vessel.

For each instrument menu, it is possible to adjust settings, switch operating modes, look at trends, set or deactivate alarms, and read trends.

Read the dedicated section of the Instrumentation course for a more thorough presentation of the HMI menus.

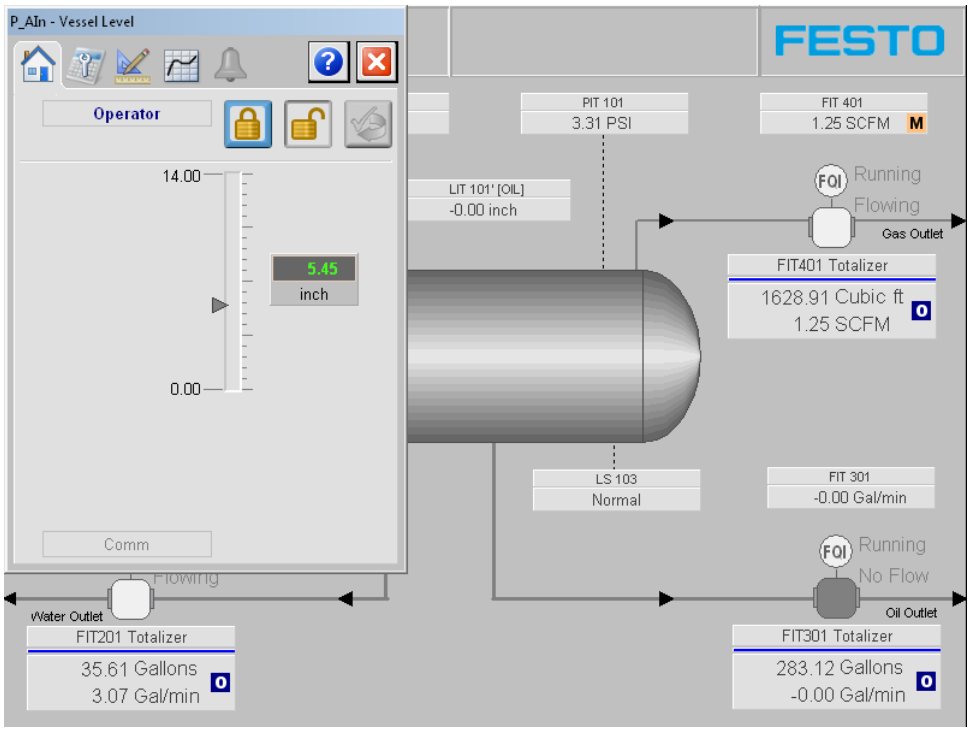

Figure 16: Water level window.

Fault switches

The Three-Phase Separator Training System is equipped with several fault switches and valves. Those are used to simulate faults on the system in troubleshooting exercises. They are hidden with small plates so the simulated faults are more subtle.

There are four fault valves installed on pneumatic lines on the learning system:

- On the input of the float level controller.
- On its output, before the oil level control valve.
- On the input of the displacer level controller.
- On its output, before the water level control valve.

These valves block pressure changes in the level control air lines. This simulates either a jammed or a disconnected air line.

Additionally, there are fault switches on the connection box of each instrument of the learning system. They cut the 4-20 mA signal loop between the instrument and the HMI. This gives the same result as a disconnected wire or a defective instrument.

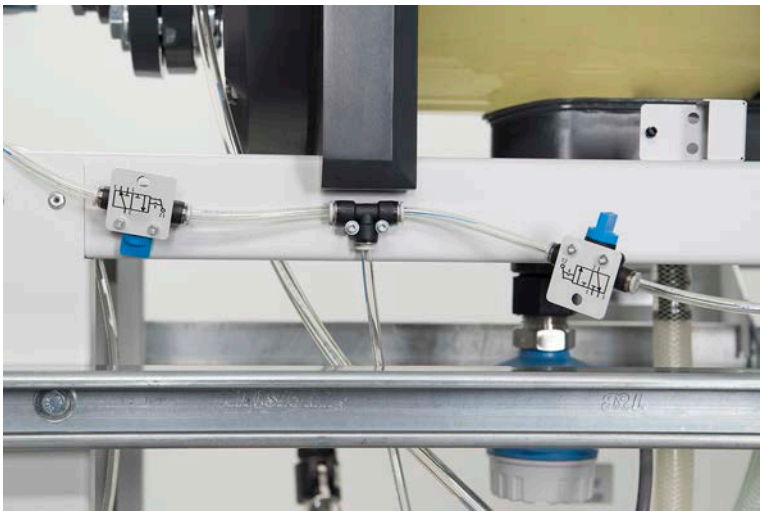

Figure 17: Fault valves.

Another type of faults can be inserted into the system with bypass valves. The water and oil output valves both are equipped with a bypass valve. This permits the emptying of the vessel once it is finished manipulating for the day and also simulates problems that can happen in the industry. The back pressure regulator also has a bypass valve to simulate a failure of this device on a separator.

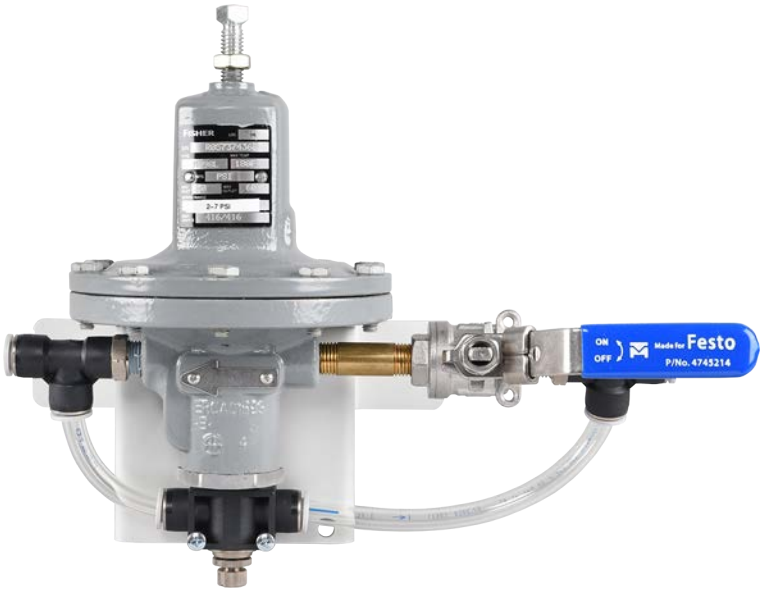

Figure 18: Back pressure regulator with a bypass valve.

Flow Instrumentation

The Three-Phase Separator Training System includes three rotameters to measure the input of oil, water, and air.

Additionally, the instrumentation set of the system includes different flow measurement instruments:

- Two turbine flowmeters for the output of water and oil to the sale lines (Model 588333).
- A differential-pressure flowmeter with an orifice plate for the output of air (Models 582410 and 8096149).
- An optional electromagnetic flowmeter for the output of water (Model 582413).
- An optional Coriolis flowmeter for the output of oil (Model 588323).

About rotameters

A rotameter measures a flow of fluid with a float, called a bob, inside a tapered tube. The fluid flows from the bottom to the top of the tube, pushing against the bob. To read the measurement, the user looks at the graduation on the tube next to the top of the bob.

The rotameter board of the learning system includes three knobs to adjust the input flow of air, water, and oil. They do not require configuration or adjustment. Both liquid rotameters can set flow rates up to 14 L/min (3.5 gpm) and the gas rotameter can set a flow rate up to 110 slpm (4 scfm). The three rotameters are specifically calibrated for the fluid they measure.

Figure 19: Rotameters board.

About turbine flowmeters

A turbine flowmeter measures the flow of liquid in a pipe with the rotation of a turbine. The rotation speed is proportional to the flow inside the pipe. A sensor in the flowmeter picks up the rotation speed, usually by electromagnetic induction.

The user may have to set the configuration of the flowmeters to use them. If it is not needed, it is still a good exercise to do. For details, please refer to documentation provided by the manufacturer and the procedure of the Instrumentation course.

Figure 20: Turbine flowmeter.

Description of the supplied turbine flowmeters

Learning outcome

After completing this section, you will be able to:

- Describe the specific characteristics of the turbine flowmeters and transmitter provided with the system.

Two turbine flowmeters are supplied with the system. They measure the output of water and oil separated in the vessel and going to the sale line. They use the HART communication protocol. The flowmeters are identified by a tag attached to the housing. For details, please refer to documentation provided by the manufacturer.

Table 13: Turbine flowmeter specifications.

Operating range	68 to 680 L/h (0.3 to 3 gal/min)
Internal diameter	9.53 mm (3/8 in)
Maximum output frequency	1100 pulses/s
Temperature range	–55°C to 121°C (–67°F to 250°F)
Pressure loss at maximum flow rate	28 kPa (4.0 psig)
Accuracy	± 1%

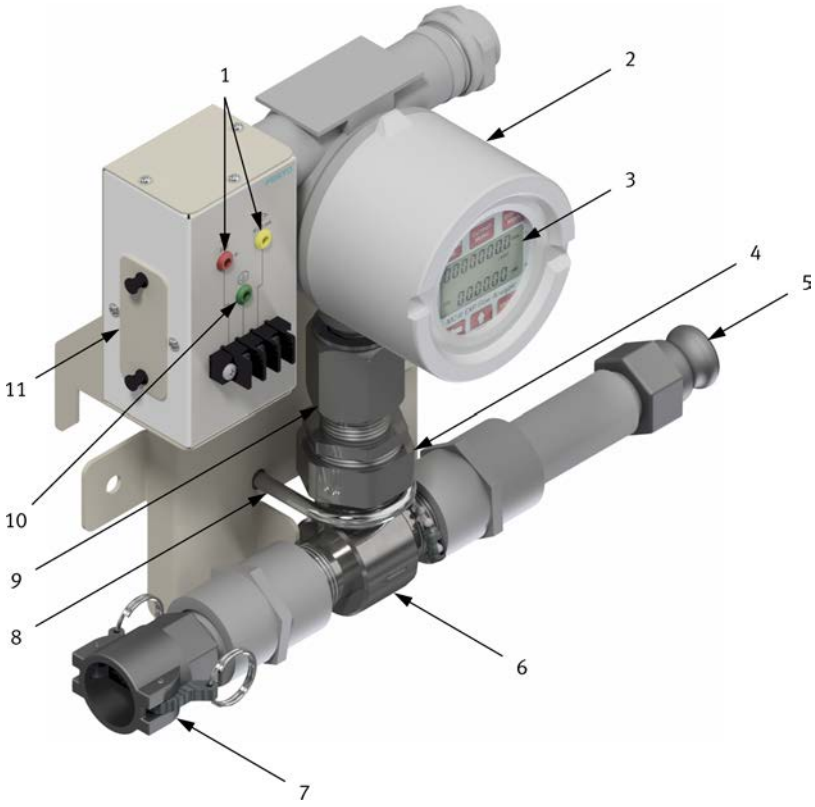

Figure 21: Turbine flowmeter.

1. **Electrical connectors**. The unit is powered through the red 24 V dc connector while the electrical signal corresponding to the sensed flow rate is sent to the controller through the 4-20 mA yellow connector.

2. **Cover**. Protects the screen and operating keys. Remove it to access the operating keys. Always put the cover back in place to avoid water or dirt accumulation inside the transmitter housing.

3. **Screen**. Displays the value of the measured variable and the general status of the transmitter.

4. **K factor plate**. This is where the value of the K factor determined for the turbine flowmeter is written. This is the value you will have to enter when calibrating the flowmeter.

5. **Input port**. Fluid must enter the flowmeter from this port.

6. **Turbine casing**. Oil or water passing through the piping exert a force pushing on the blades of the turbine and making it turn. The rotation of the rotor of the turbine is caught by the sensor.

7. **Output port**. Fluid must exit the flowmeter from this port.

8. **Mounting bracket**. Used to secure the instrument to the mounting pipe of the process workstation. Never attempt to loosen any of the bolts and nuts that are partly covered with an orange coating. This would void the warranty of the instrument and could cause irreversible damage to the sensing element.

9. **Setscrew**. Do not loosen the setscrew. The transmitter cannot be rotated relative to the sensing element.

10. **Ground connector**. Protective connection terminal.

11. **Fault switch**. Activates or deactivates the transmitter. Your instructor can use this switch to insert a fault in the current loop. Always verify the position of this switch when troubleshooting the transmitter.

The body, vanes and flanges of the provided flowmeters are made of stainless steel. The shaft and bearings are made of tungsten carbide, so they are made to withstand harsh conditions and mechanical stress.

Table 14: Keys and functions.

Key	Function
← LOG	**During calibration**. Navigate between submenus and scroll through menu selections. **During operation**. Access daily volume archive.
↑ TEST	**During calibration**. Increment digits and decimal point position, turn on/off settings. **During operation**. Test temperature and system voltage.
ENTER SAVE	**During calibration**. Save calibration settings. **During operation**. Save total to nonvolatile memory.
K-FACTOR MENU	Calibrate instrument, set flowmeter input sensitivity, select pulse input.
OUTPUT MENU	Enable/disable/set up 4-20 mA and pulse output, enter slave address and baud rate.
DISPLAY MENU	Set units for total and rate readout, set decimal placement for both readouts.

Pressing both ←/LOG and ENTER/SAVE buttons at the same time resets the totalizer readout to zero.

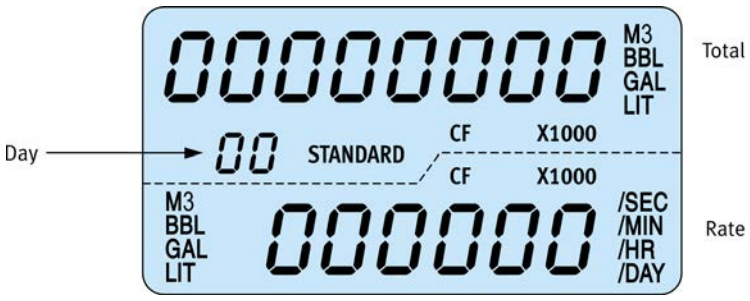

Figure 22: Turbine flowmeter display.

The provided turbine flowmeters have a liquid-crystal display. The top value is the totalized flow and the bottom one is the flow rate. The middle number on the left side of the display is the daily index value. Only the selected units of measurement are visible during operation of the flowmeter.

About DP flowmeters and orifice plates

A differential-pressure (DP) flowmeter measures a pressure difference between two points. It needs a device to help it evaluate the flow rate of a fluid. In this case, this device is an orifice plate. An orifice plate is a small metallic plate with a hole in the middle. When passing through the hole, the flow of fluid undergoes a pressure drop. The flowmeter measures this pressure difference and it calculates the corresponding flow rate.

The user may have to set the configuration of the flowmeter to use it. If it is not needed, it is still a good exercise to do. For details, please refer to documentation provided by the manufacturer and the procedure of the Instrumentation course.

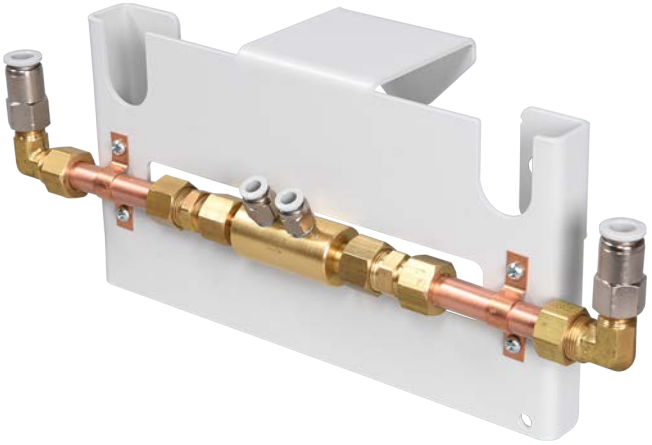

Figure 23: Orifice assembly.

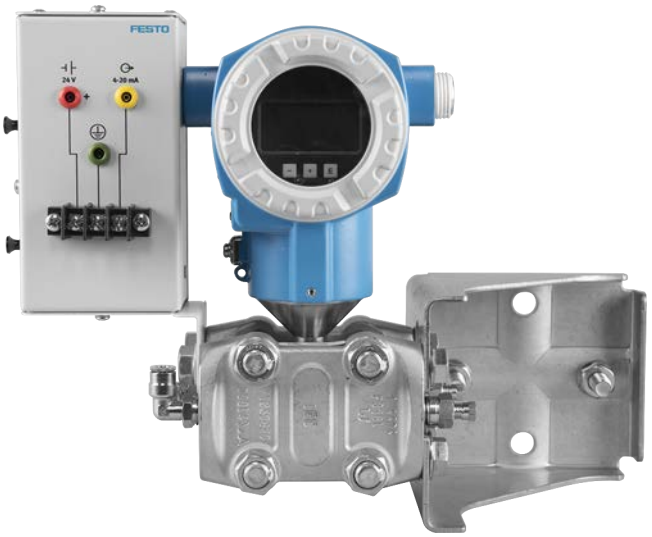

Figure 24: Differential-pressure transmitter.

Description of the supplied differential-pressure flowmeter and orifice plate

Learning outcome

After completing this section, you will be able to:

- Describe the specific characteristics of the orifice plate and DP transmitter provided with the system.

One differential pressure transmitter is supplied with the system. It measures the flow of air coming out of the vessel, representing natural gas separated from oil and water. It uses the HART communication protocol. The transmitter is identified by the tag attached to the housing. For details, please refer to documentation provided by the manufacturer.

Table 15: DP transmitter specifications.

Lower range limit (LRL)	50 kPa (7.5 psia)
Upper range limit (URL)	16,000 kPa (2400 psia)
Precision	± 0.075%
Pressure-sensitive device	Deltabar metallic diaphragm
Electronic sensor	Piezoresistive cell
Cell condition	Exposed to pressure on both sides for relative pressure measurement

Table 16: Orifice plate body specifications.

Mounting position	Preferably horizontal
Direction	Flow must be in the direction indicated by the arrow
Pressure taps position	Above orifice plate for gases
Pipe inside diameter (D)	9.93 mm (0.391 in)
Orifice diameter (d)	4.98 mm (0.196 in) $\beta = 0.50$

On the Three-Phase Separator Learning System, the orifice plate is placed inside a prefabricated body (see the following figure). However, it is common to see removable orifice plates placed between two flanges in the piping. Such a design can be convenient because the orifice plate can be easily changed and maintained, and the piping can be cleaned if it gets clogged or if there is an accumulation of material near the plate. On the other hand, a removable orifice plate can pose a risk of leaking.

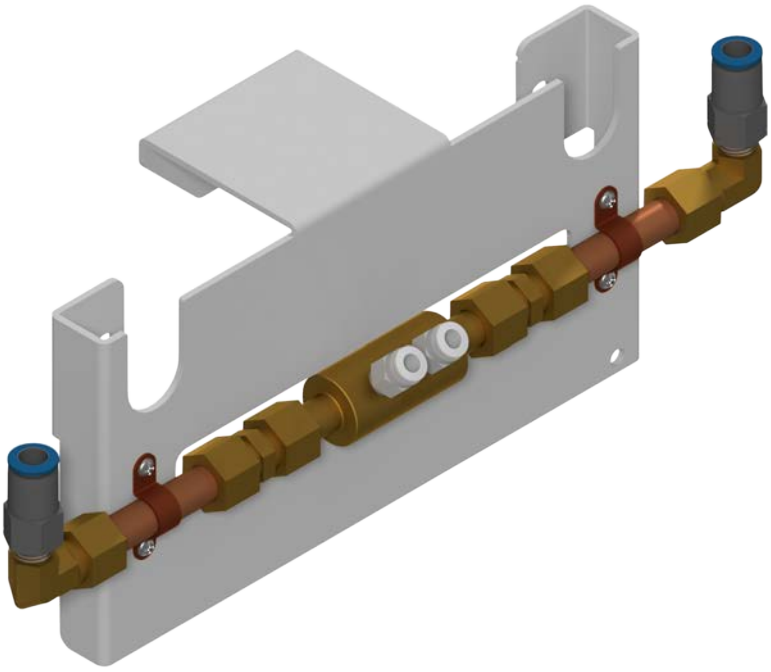

Figure 25: Orifice plate body.

The following figure shows the supplied DP transmitter. Each part is described below.

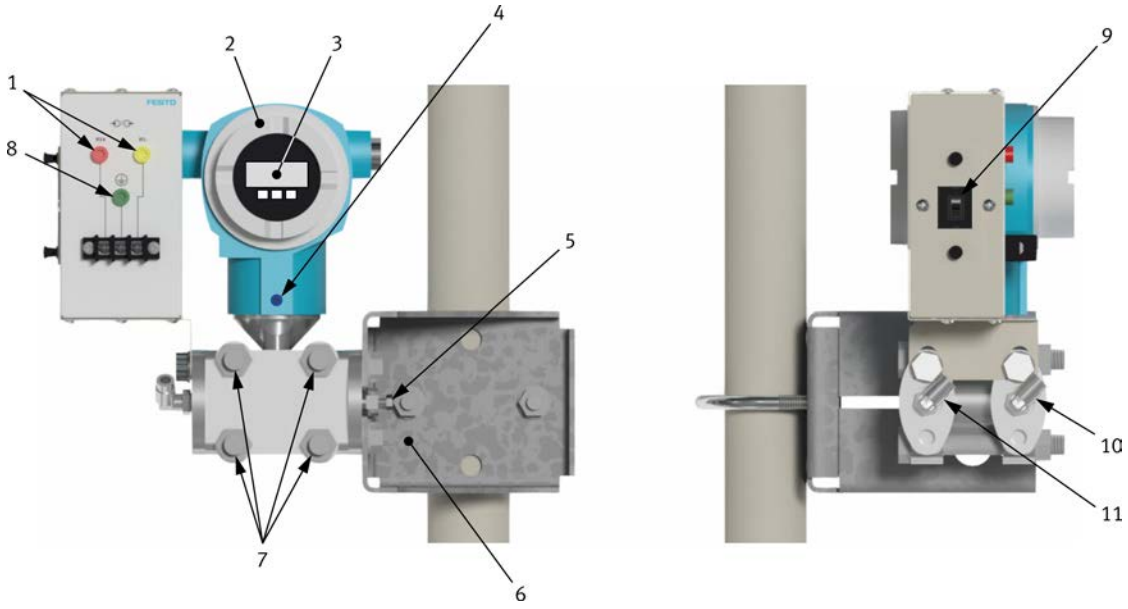

Figure 26: DP Transmitter supplied with the system.

1. **Electrical connectors.** The unit is powered through the red 24 V dc connector while the electrical signal corresponding to the measured flow rate is sent to the controller through the 4-20 mA yellow connector.

2. **Cover.** Protects the screen and operating keys. Remove it to access the operating keys. Always put the cover back in place to avoid water or dirt accumulation inside the transmitter housing.

3. **Screen.** Displays the value of the measured variable, the various menus and the general status of the transmitter.

4. **Setscrew.** Do not loosen the setscrew. The transmitter cannot be rotated relative to the sensing element. If you need to rotate the transmitter, rotate it as a whole around the mounting pipe of the process workstation.

5. **Vent valves.** Used to purge (the term bleed is often used) the impulse lines and sensing element of any unwanted fluid that would alter measurements.

6. **Mounting bracket.** Used to secure the instrument to the mounting pipe of the process workstation. Do not install the DP transmitter elsewhere on the station unless authorized by your instructor.

7. **Assembly bolts and nuts.** Never attempt to loosen any of the bolts and nuts that are partly covered with an orange coating. This would void the warranty of the instrument and could cause irreversible damage to the sensing element.

8. **Ground connector.** Protective connection terminal.

9. **Fault switch.** Activates or deactivates the transmitter. Your instructor can use this switch to insert a fault in the current loop. Always verify the position of this switch when troubleshooting the transmitter.

10. **Low pressure inlet.** Connect the impulse line carrying the lower pressure to this inlet.

11. **High pressure inlet.** Connect the impulse line carrying the higher pressure to this inlet.

Display

The following table describes each key.

Table 17: Keys and functions.

Key	Function
−	Navigate downward in a list or edit a value.
+	Navigate upward in a list or edit a value.
E	Confirm an entry or jump to the next item.
+ −	Escape, go up a level in a menu or exit without saving.

You can adjust the contrast on the screen by pressing simultaneously **E** and **+** or **E** and **–**.

The screen displays menu items, information about the measured variable and status of the transmitter. A description of the most important details is given below.

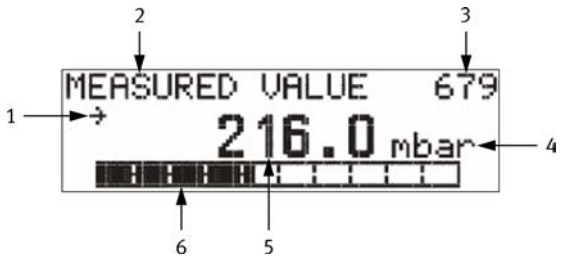

Figure 27: Display details.

1. **Symbol.** Gives information about the status of the transmitter:

Table 18: Symbols used in the display.

Symbol	Meaning
	**Alarm.** An alarm message is displayed. A flashing symbol means the transmitter continues to measure, while a permanently lit symbol means the device has halted measuring.
	**Lock.** The transmitter is locked against unauthorized access. You can navigate through the menus but cannot modify most parameters.
	**Communication.** The transmitter is exchanging data with an external device such as a computer or handheld.
	**Square root.** Indicates that the flow rate measurement mode is active.
	**Tendency.** Indicates whether the measuring value is respectively increasing, decreasing or remaining constant.

2. **Function name**. Displays the current function.
3. **Parameter number**. Each parameter is given a three-digit ID for reference.
4. **Unit**. The unit of the measured value chosen by the user. The unit depends on the measuring mode selected.
5. **Measured value**. Current measured value.
6. **Bar graph**. Displays the current percentage of the measured value relative to its maximum value.

About electromagnetic flowmeters

An electromagnetic flowmeter measures a flowrate of liquid using a magnetic field. It measures the induced voltage created by the flow of liquid in a pipe to calculate the desired value. This liquid has to be conductive for this device to work, so it can only be installed on the sale line of water running out of the vessel.

The user may have to set the configuration of the flowmeter to use it. If it is not needed, it is still a good exercise to do. For details, please refer to documentation provided by the manufacturer and the procedure of the Instrumentation course.

Figure 28: Electromagnetic flowmeter.

Description of the supplied electromagnetic flowmeter

Learning outcome

After completing this section, you will be able to:

- Describe the specific characteristics of the electromagnetic flowmeter and transmitter provided with the system.

One electromagnetic flowmeter can be supplied with the system. It measures the output of water separated in the vessel and going to the sale line. It uses the HART communication protocol. The flowmeter is identified by a tag attached to the housing. For details, please refer to documentation provided by the manufacturer.

Table 19: Electromagnetic flowmeter specifications.

Operating range	4 to 100 L/min (1 to 25 gal/min)
Temperature range	–40°C to 180°C (–40°F to 350°F)
Maximum pressure	4000 kPa (580 psi)
Internal diameter	1.27 cm (1/2 in)
Accuracy	± 0.5%
Minimum conductivity	≥ 5 µS/cm

The electromagnetic flowmeter supplied with the system is shown in the following figure. It consists of a sensor including a transmitter and a bracket.

The connection box is used to connect the electromagnetic flowmeter to various devices such as a handheld or portable computer, a controller, or a programmable logic controller (PLC).

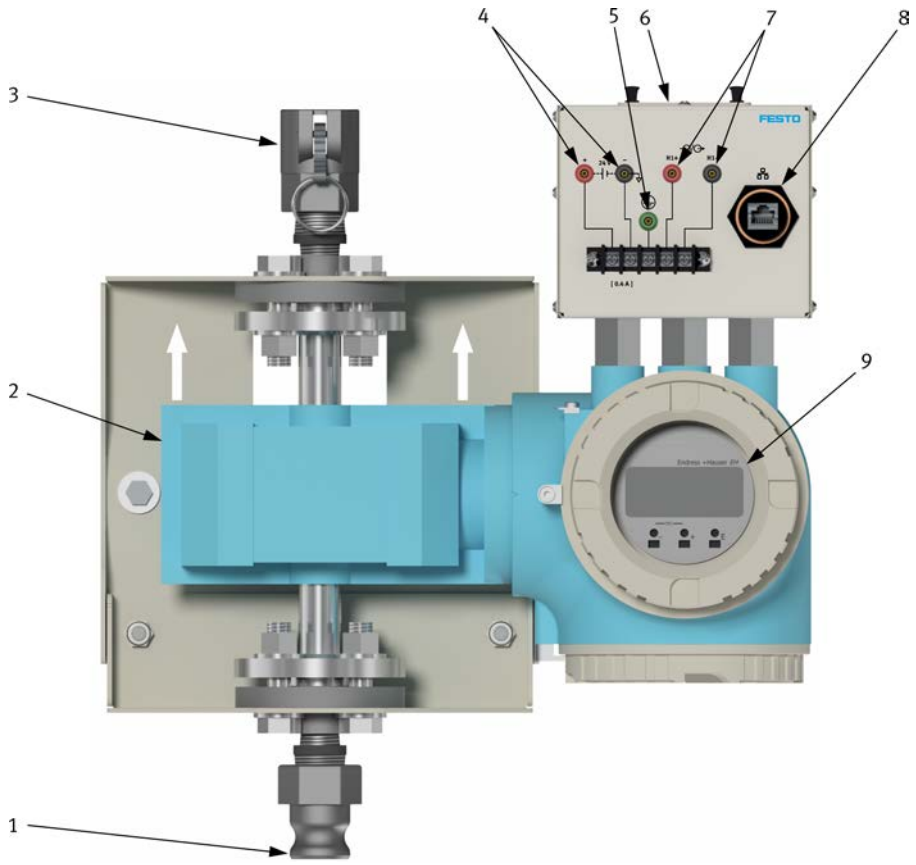

Figure 29: Supplied electromagnetic flowmeter.

1. **Input port.** Fluid must enter the flowmeter from this port.

2. **Flow orientation arrow.** Indicates the required direction of flow. Make sure to follow this instruction.

3. **Output port.** Fluid must exit the flowmeter from this port.

4. **24 V dc input.** Power input for the flowmeter. Used to energize the electromagnetic flowmeter with a 24 V dc signal.

5. **Ground connector.** Protective connection terminal.

6. **Fault panel.** Contains switches used to simulate a fault with the apparatus.

7. **HART communication port.** Sends a 4-20 mA signal proportional to the measured flow which can be used with the HART protocol to interface the flowmeter with a computer or with other devices.

8. **Additional port.** This flowmeter can be linked to another device using an Ethernet cable.

9. **Digital display.** Displays the measured flow rate and other information related to the operation of the flowmeter. The protective cover can be removed to gain access to the control keys and to manually control the device.

The transmitter has a built-in display that can be used to configure several parameters and to read the flow rate directly.

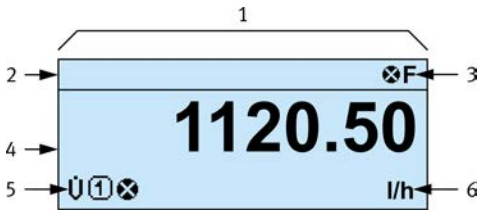

Figure 30: Electromagnetic flow transmitter display.

1. Operational display

2. Device tag

3. Status area. Refer to the following table.

Table 20: Status signals.

Status signal	Meaning
F	Failure
C	Function check
S	Out of specifications
M	Maintenance required
⊗	Alarm
⚠	Warning

4. Display area for measured values
5. Measurement symbols. The number in the box is the measurement channel in use. Refer to the following table.
6. Unit

Table 21: Measurement symbols.

Symbol	Meaning
$\dot{V}$	Volume flow
G	Conductivity
$\dot{m}$	Mass flow
Σ	Totalizer
	Output
	Status input

Table 22: Keys and functions.

Key	Function
−	Navigate downward in a list or edit a value.
+	Navigate upward in a list or edit a value.
E	Confirm an entry or jump to the next item.
+ AND −	Escape, go up a level in a menu or exit without saving.

About Coriolis flowmeters

A Coriolis flowmeter measures the mass flow of liquid flowing through a pipe. It uses the Coriolis effect, hence the name. The liquid passes into a curved oscillating tube inside the flowmeter. When that liquid is moving, it opposes the oscillating movement and slightly bends the tube. That creates a time lag in the oscillation. Since the time lag is proportional to the mass of liquid flowing through the tube, the flowmeter can calculate this value and display it.

The user may have to set the configuration of the flowmeter to use it. If it is not needed, it is still a good exercise to do. For details, pleaserefer to documentation provided by the manufacturer and the procedure of the Instrumentation course.

Figure 31: Coriolis flowmeter.

Description of the supplied Coriolis flowmeter

Learning outcome

After completing this section, you will be able to:

- Describe the specific characteristics of the Coriolis flowmeter and transmitter provided with the system.

One Coriolis flowmeter can be supplied with the system, as an option. It measures the output of oil separated in the vessel and going to the sale line. The Coriolis flowmeter uses the HART communication protocol. The flowmeter is identified by a tag attached to the housing. For details, please refer to documentation provided by the manufacturer.

Table 23: Coriolis flowmeter specifications.

Operating range	0 to 22.7 kg/min (0 to 50 lb/min)
Maximum temperature	150°C (302°F)
Inner diameter	1.27 cm (1/2 in)
Accuracy	± 0.10% mass
Sensor setting	Dual tubes

The following figure shows the Coriolis flow transmitter. It consists of a sensor and a transmitter with a bracket for mounting the device on the learning system.

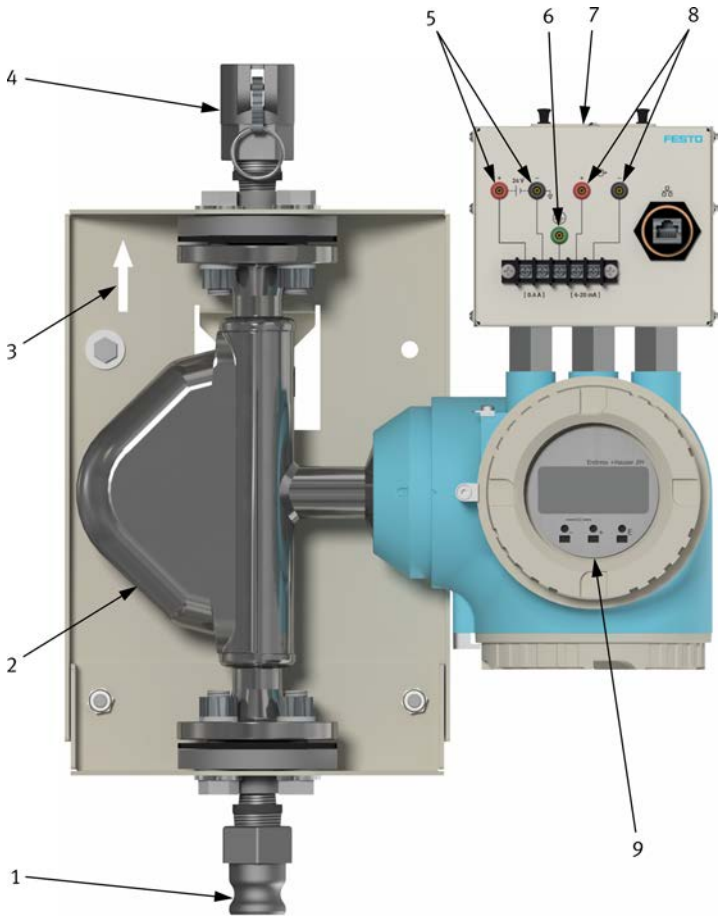

Figure 32: Coriolis flow transmitter.

1. **Inlet.** Fluid must enter the flowmeter from this port.

2. **Sensor.** The sensor assembly containing the flow tubes.

3. **Flow orientation arrow.** Indicates the required direction of flow. Be sure to follow this instruction.

4. **Outlet.** Fluid must exit the flowmeter from this port.

5. **24 V dc input.** Power input for the flowmeter. It is used to energize the electromagnetic flowmeter with a 24 V dc signal.

6. **Ground connector.** Protective connection terminal.

7. **Fault panel.** Contains one switch used to simulate a fault with the apparatus.

8. **Analog output/ HART communication port.** Sends a 4-20 mA signal proportional to the measured mass flow rate. HART communication can also be established with various devices such as a handheld or portable computer, a controller, or a programmable logic controller (PLC) using this port.

9. **Digital display.** Displays the measured flow rate and other information related to the operation of the flowmeter. The protective cover can be removed to gain access to the control keys.

The transmitter has a built-in display that can be used to configure several parameters and to read the flow rate directly.

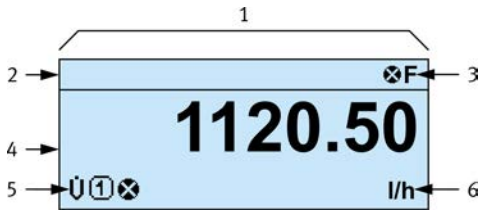

Figure 33: Coriolis flow transmitter display.

1. Operational display
2. Device tag
3. Status area:

Table 24: Status signals.

Status signal	Meaning
F	Failure
C	Function check
S	Out of specifications
M	Maintenance required
	Alarm
	Warning

4. Display area for measured values
5. Measurement symbols; the number in the box is the measurement channel in use.

Table 25: Measurement symbols.

Symbol	Meaning
$\dot{m}$	Mass flow
$\dot{v}$	Volume flow
ρ	Density
	Temperature
Σ	Totalizer
	Output
	Status input

6. Unit

Table 26: Keys and functions.

Key	Function
−	Navigate downward in a list or edit a value.
+	Navigate upward in a list or edit a value.
E	Confirm an entry or jump to the next item.
+ AND −	Escape, go up a level in a menu or exit without saving.

Level Instrumentation

Real-life three-phase separators rely on level control and measurement for the separation process. This is why several components of the Three-Phase Separator Learning System measure and control levels.

Mainly, a float controls the level of oil and displacer controls the level of water inside the vessel. Additionally, there are level-related devices in the instrumentation package:

- Tuning forks level switches to detect levels (Model 8092031).
- A multiparameter radar level meter to measure levels (Model 8098928).

Float and displacer level controllers

Float level controller

Figure 34: Float level controller of the learning system.

The level in the oil output section is controlled with a float. It is a simple device using buoyancy, like the float inside a conventional flush toilet. The float follows the level of separated oil in the output section. When that level reaches the setpoint of the controller, it sends air pressure to the oil level control valve. The valve opens and it allows the liquid to flow out to keep the level within a certain range. Once the level is inside the range, the controller closes the valve.

Displacer level controller

Figure 35: Displacer level controller of the learning system.

The displacer level controller keeps the level of water in the vessel within the operating range. It works in a way similar to the float. It follows the interface between the water and the oil. The buoyancy caused by the displacement of liquid by the displacer applies a force on it. When that force is stronger than the setting of the controller, it sends air pressure to the water level control valve. Water flows out until the displacer reaches its minimal level. The controller cuts air pressure sent to the valve and it closes.

It is possible to adjust the spring of the displacer to configure its setpoint and sensitivity as to modify the retention time of the oil in the vessel. Follow the appropriate procedure in the Basic Operation course, or documentation provided by the manufacturer.

About tuning forks

Tuning forks are devices that vibrate to detect the presence or absence of material in a vessel. They work using two piezoelectric crystals. One vibrates when a voltage is applied, while the second is used as a sensor. If material touches the tines of the fork, vibrations are damped, and that is noticed by the sensor.

Tuning forks are not used for measurement, only to detect if a level is above or below a point. Normally, they should not require any configuration. If it is needed, read the appropriate section of the Instrumentation course or the manufacturer's documentation.

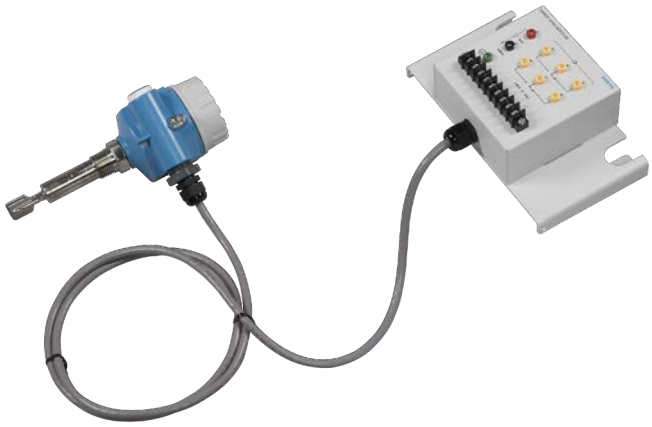

Figure 36: Tuning forks level switch.

Description of the supplied tuning fork level switches

Learning outcome

After completing this section, you will be able to:

- Describe the specific characteristics of the tuning fork level switches provided with the system.

There are three tuning forks level switches provided the Three-Phase Separator Learning System. They use the HART communication protocol. The transmitters are identified by a tag attached to the housing. For details, please refer to the documentation provided with the device.

Table 27: Tuning fork level switch specifications.

Temperature of the process	–50°C to 150°C (–58°F to 300°F)
Maximum pressure	10 000 kPa (1450 psi)
Maximum viscosity	10 000 mm²/s (10 000 cP)
Density	Below 0.5 g/cm³ (0.5 SUG) or above 0.7 g/cm³ (0.7 SUG)
Relays	DPDT (19 to 250 V ac or 19 to 55 V dc)
Length of the tines	200 mm (7.87 in)

The tuning level switch designed for the Three-Phase Separator Training System is shown in the following figure. A remote connection box on the back of the system gives access to the contacts of the switch.

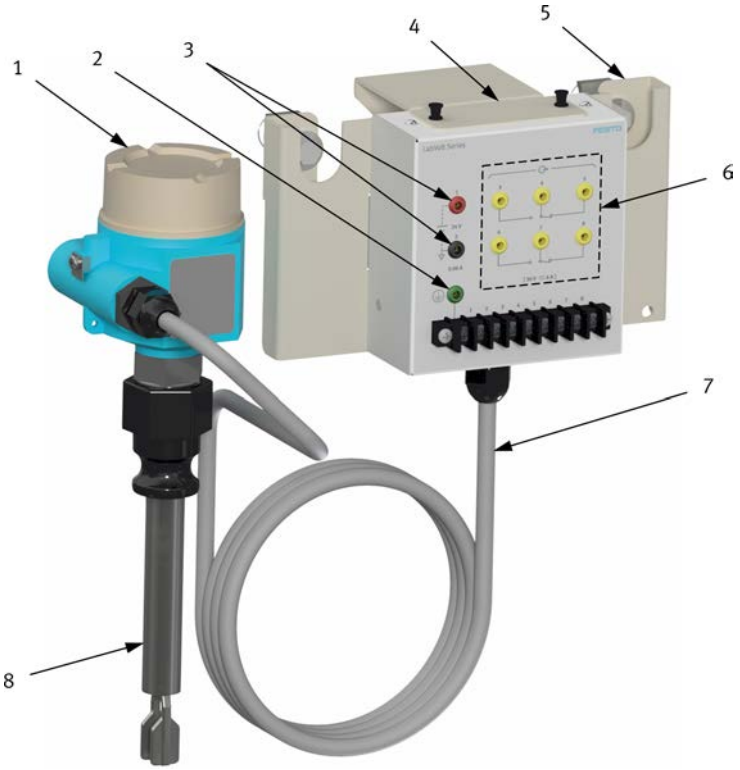

Figure 37: Tuning fork level switch.

1. **Switch housing.** The housing contains a DPDT relay actuated when the level of process material is above (or below) the installation point. The housing cover can be removed to change some of the parameters determining the switch operation.

2. **Ground connector.** Protective connection terminal.

3. **24 V dc input.** Used to energize the switch with a 24 V dc signal.

4. **Fault panel.** Contains switches used to simulate faults with the apparatus.

5. **Mounting bracket.** Used to secure the instrument to the mounting pipe of the process workstation. Never attempt to loosen any of the bolts and nuts that are partly covered with an orange coating. This would void the warranty of the instrument and could cause irreversible damage to the sensing element.

6. **Contacts connectors.** Connectors for the contacts of the DPDT relay.

7. **Remote connection box cable.** A cable connects the remote connection box to the switch.

8. **Probe.** The probe tines are fragile; they must not be bent or damaged in any ways. When the probe is not installed on the system, the probe must be protected using the protective tube provided with the switch.

The provided level switches are located on the bottom and the top of the separation vessel, and the bottom of the oil output section. They are low- and high-limit level meters, they are present to notify the operator that the separator is either too empty or too full for normal operation. An alarm is sent to the HMI if the high-level meter is sensing liquid (Hi Hi) or if the low-level meter is not sensing any (Low Low). The low-level alarm is there to prevent gas from exiting in the oil or water line.

About radar level meters

A radar level meter uses the time-of-flight principle to measure a level. It sends pulses of microwaves down the bottom of the vessel it is placed in and measures the time it takes for this signal to come back. It can measure the level of liquids, solids, and interfaces. Some radars are non-guided while guided ones use a probe dipped into the vessel. It is possible to add other measurements, like capacitance, to a radar level meter (now called a multiparameter radar) to increase its precision or add to its interface-measuring ability.

It can be necessary to set the configuration of this meter prior to the operation of the learning system. Even if it has already been set, it can be a good exercise. To configurate the radar level meter, follow the appropriate procedure in the Instrumentation course or the manufacturer's documentation.

Figure 38: Multi-parameter radar level meter.

In this figure, the radar level meter is missing its metallic casing that is used for capacitance measurement.

Description of the supplied radar level meter

Learning outcome

After completing this section, you will be able to:

- Describe the specific characteristics of the radar level meter provided with the system.

The multiparameter radar level meter provided with the Three-Phase Separator Learning System keeps track of the levels of both oil and water inside the vessel, using both the guided-radar time-of-flight principle and the measurement of the capacitance. Level measurement and monitoring is critical as the separation process can only work within a certain level range. It uses the HART communication protocol. The transmitter is identified by the tag attached to the housing. For details, please refer to documentation provided by the manufacturer.

Table 28: Guided-radar level meter specifications.

Probe length	45.5 cm (19.5 in)
Accuracy	± 2 mm (± 0.08 in)
Temperature range	-40°C to 185°C (-40°F to 365°F)
Pressure range	-100 kPa to 1600 kPa (-14.5 psig to 232 psig)
Blocking distance	200 mm (8 in)

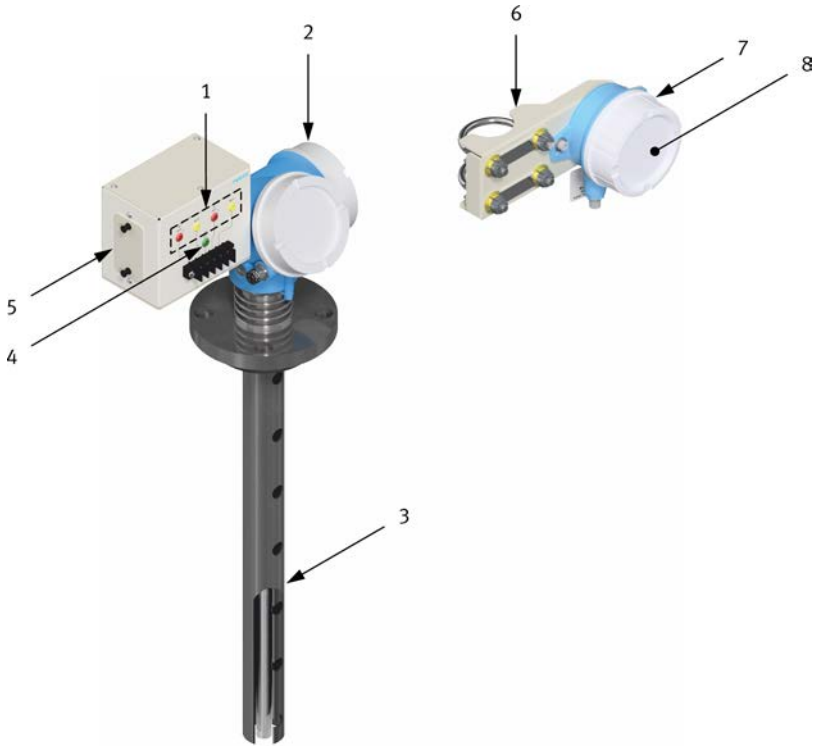

Figure 39: Guided-radar level meter.

1. **Electrical connectors.** The unit is powered through the red 24 V dc connector while the electrical signal corresponding to the level measurements is sent to the controller through the 4-20 mA yellow connector.

2. **Radar housing.** The housing contains the circuitry of the radar level meter.

3. **Probe.** The inner probe carries the frequency emitted by the radar and allows it to make a measurement. Combination of radar and capacitance measurements made by the probe ensures an accurate level measurement.

4. **Ground connector.** Protective connection terminal.

5. **Fault panel.** Contains switches used to simulate faults with the apparatus.

6. **Mounting bracket.** Used to secure the instrument to the mounting pipe of the process workstation. Never attempt to loosen any of the bolts and nuts that are partly covered with an orange coating. This would void the warranty of the instrument and could cause irreversible damage to the sensing element.

7. **Cover.** Protects the screen and operating keys. Remove it to access the operating keys. Always put the cover back in place to avoid water or dirt accumulation inside the transmitter housing.

8. **Screen.** Displays the value of the measured variable and the general status of the transmitter. Not visible on this figure, it is underneath the white cover.

Table 29: Keys and functions.

Key	Function
−	Navigate downward in a list or edit a value.
+	Navigate upward in a list or edit a value.
E	Confirm an entry or jump to the next item.
+ AND −	Escape, go up a level in a menu or exit without saving.

You can adjust the contrast on the screen by pressing simultaneously **E** and **+** or **E** and **−**.

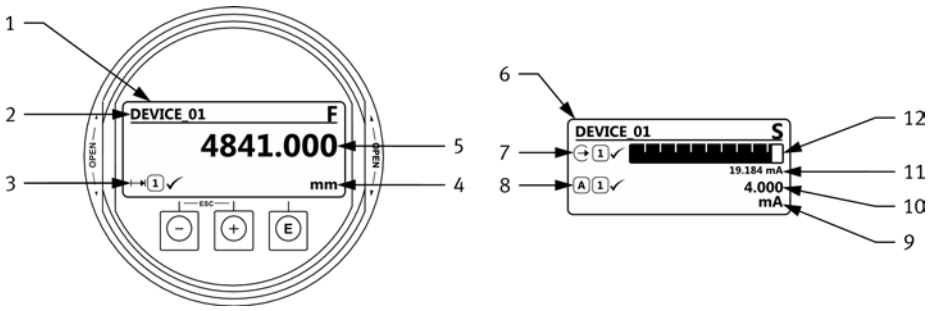

Figure 40: Appearance of the radar level meter display.

1. Measured value display (1 value with max size)
2. Header containing tag and error symbol (if an error is active)
3. Measured value symbols; the number in the box is the measurement channel in use.
4. Unit

5. Measured value
6. Measured value display (1 bar graph + 1 value)
7. Measured value symbols for measured value 2
8. Measured value symbols for measured value 1
9. Unit for measured value 2
10. Measured value 2
11. Measured value 1 (including unit)
12. Bar graph for measured value 1

Table 30: Status signals.

Status signal	Meaning
F	**Failure.** A device error is present, the measured value is no longer valid.
C	**Function check.** The device is in service mode, like during a simulation.
S	**Out of specification.** The device is operated outside of its technical specifications (e.g. during a startup or cleaning), outside of the configuration carried out by the user (e.g. level outside configuration range).
M	**Maintenance required.** The measured value is still valid.
	**Status alarm.** The measurement is interrupted. The output assumes the defined alarm value. A diagnostic message is generated.
	**Status warning.** The device continues measuring. A diagnostic message is generated.
	**Level measured.** This reading is a measurement from the bottom of the vessel to the surface of the liquid.
	**Distance measured.** This reading is a measurement from the flange of the radar level meter to the surface of the liquid.

Pressure Instrumentation

Pressure measurement and control is crucial in a three-phase separator. The efficiency of the separation process depends in great part on the management of the pressure inside the vessel. It is also very important for the safety of the process.

A pressure gauge is attached to the vessel of the Three-Phase Separator Learning System. The instrumentation package also includes a pressure transmitter (Model 588333).

About pressure meters

Pressure measurement is essential in pressurized equipment like a three-phase separator. An analogic pressure gauge shows the user the pressure inside the vessel. Additionally, a digital pressure meter is included in the instrumentation.

The gauge is placed at the top of the vessel. It uses a Bourdon tube to make measurements. This is a small bent metallic tube that deforms itself when pressure is applied on it. This deformation moves a mechanism that guide a hand on a dial to show the measured pressure.

The gauge does not need to be configured or adjusted.

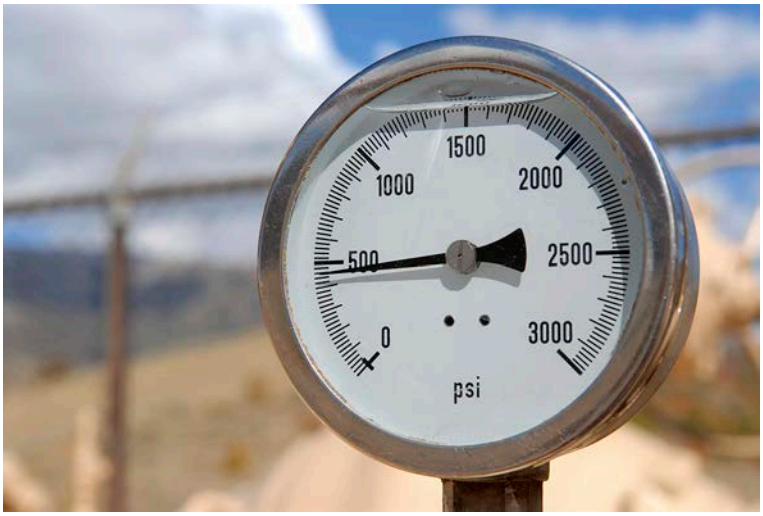

Figure 41: Typical pressure dial gauge.

The pressure meter of the Three-Phase Separator Learning System uses a capacitive cell to measure the pressure in the vessel to display it on the screen of the HMI. The air pressure in the vessel presses against a diaphragm that pushes against the cell to make a measurement. A capacitive cell senses pressure by the measurement of the capacitance between two electrodes. As this electric property is dependent on the distance between the electrodes, it is possible to find the pressure applied on the cell.

It may be necessary to configure the meter before using the separator. Follow the appropriate procedure in the Instrumentation course or the manufacturer's documentation.

Figure 42: Pressure meter.

Description of the supplied pressure meter

Learning outcome

After completing this section, you will be able to:

- Describe the specific characteristics of the pressure meter provided with the system.

The Three-Phase Separator Learning System contains a pressure meter which measures and keeps track of the air pressure inside the vessel. Pressure is not controlled by the system, the meter only makes readings available on the HMI. It uses the HART communication protocol. The transmitter is identified by the tag attached to the housing. For details, please refer to documentation provided by the manufacturer.

Table 31: Pressure meter specifications.

Parameter	Value
Maximum operating pressure	1000 kPa (150 psig)
Accuracy	± 0.075%
Pressure-sensitive device	Ceraphire ceramic diaphragm
Electronic sensor	Capacitive cell
Cell condition	Held to absolute vacuum

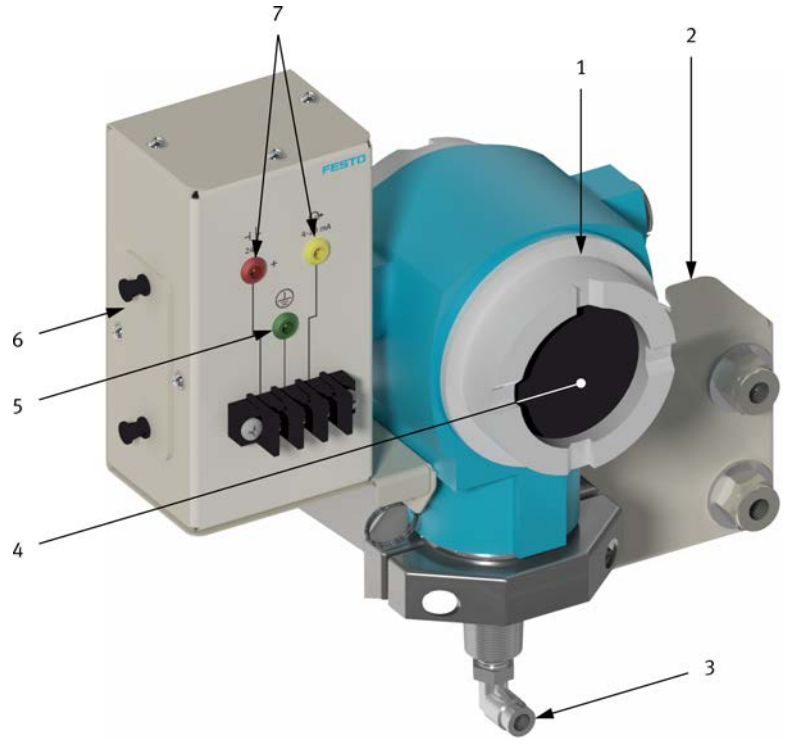

Figure 43: Pressure meter.

1. **Cover.** Protects the screen and operating keys. Remove it to access the operating keys. Always put the cover back in place to avoid water or dirt accumulation inside the transmitter housing.

2. **Mounting bracket.** Used to secure the instrument to the mounting pipe of the process workstation. Never attempt to loosen any of the bolts and nuts that are partly covered with an orange coating. This would void the warranty of the instrument and could cause irreversible damage to the sensing element.

3. **Pressure inlet.** The impulse line carrying the pressure is connected to this inlet.

4. **Screen.** Displays the value of the measured variable, the various menus and the general status of the transmitter.

5. **Ground connector.** Protective connection terminal.

6. **Fault switch.** Activates or deactivates the transmitter. Your instructor can use this switch to insert a fault in the current loop. Always verify the position of this switch when troubleshooting the transmitter.

7. **Electrical connectors.** The unit is powered through the red 24 V dc connector while the electrical signal corresponding to the measured pressure is sent to the controller through the 4-20 mA yellow connector.

Table 32: Keys and functions.

Key	Function
–	Navigate downward in a list or edit a value.
+	Navigate upward in a list or edit a value.
E	Confirm an entry or jump to the next item.
+ and –	Escape, go up a level in a menu or exit without saving.

You can adjust the contrast on the screen by pressing simultaneously **E** and **+** or **E** and **–**.

The screen displays menu items, information about the measured variable and status of the transmitter. A description of the most important details is given below.

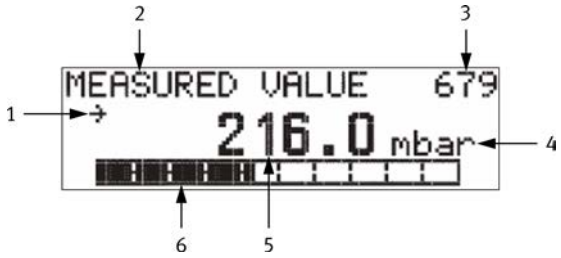

Figure 44: Display details.

1. **Symbol.** Gives information about the status of the transmitter:

Table 33: Symbols used on the display.

Symbol	Meaning
	**Alarm**. An alarm message is displayed. A flashing symbol means the transmitter continues to measure, while a permanently lit symbol means the device has halted measuring.
	**Lock**. The transmitter is locked against unauthorized access. You can navigate through the menus but cannot modify most parameters.
	**Communication**. The transmitter is exchanging data with an external device such as a computer or handheld.
	**Square root**. Indicates that the flow rate measurement mode is active.
	**Tendency**. Indicates whether the measuring value is respectively increasing, decreasing or remaining constant.

2. **Function name.** Displays the current function.

3. **Parameter number.** Each parameter is given a three-digit ID for reference.

4. **Unit.** The unit of the measured value chosen by the user. The unit depends on the measuring mode selected.

5. **Measured value.** Current measured value.

6. **Bar graph.** Displays the current percentage of the measured value relative to its maximum value.

Temperature Instrumentation

Just like level and pressure, a good control and measurement of the temperature is critical for a good separation and to ensure the safety of the process. A temperature transmitter can be included in the instrumentation package of the Three-Phase Separator Learning System (Thermocouple Model 582406, Transmitter Model 582422).

About thermocouples

A simple and common way of measuring a temperature is by using a thermocouple. It is a small probe made of two different metals placed in contact. When heat is applied on the junction, a small current is created as electrons in the metal jump across the junction. When that thermocouple is placed in the closed circuit of a transmitter, it is possible to determine the temperature by measuring that current. Types of thermocouple are standardized for different temperature ranges. For protection, the thermocouple is often placed inside a sheath or a steel casing, called a thermowell.

The user does not need to configure the meter before using the separator. Follow the appropriate procedure in the Instrumentation course or the manufacturer's documentation if needed. To change the configuration of the temperature transmitter, connect to the device in order to use the Fieldcare software. The software and the communication box are not included with the learning system.

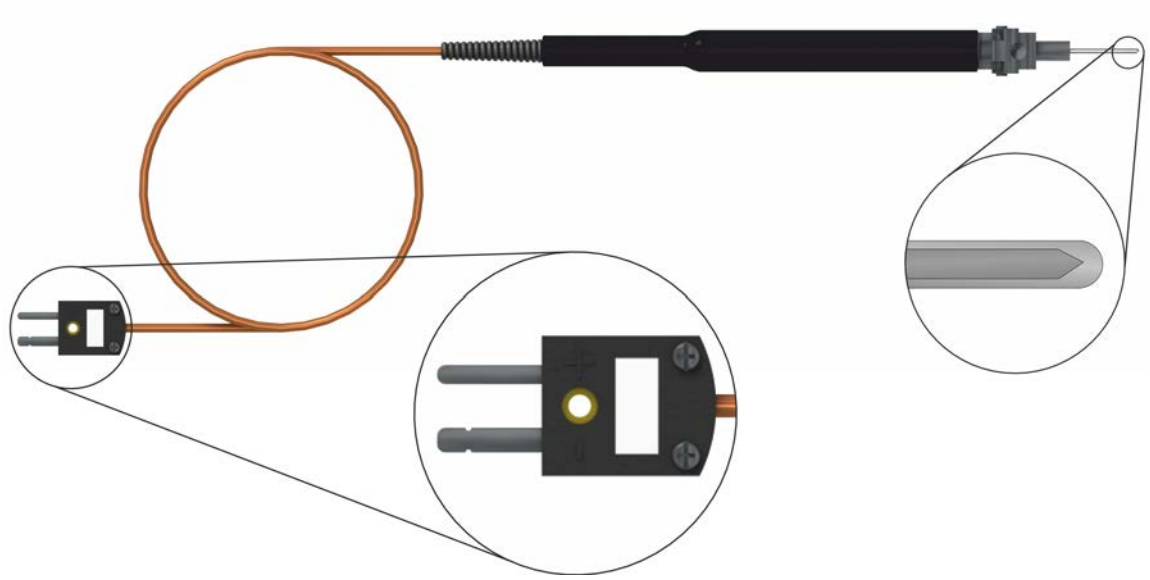

Figure 45: Example of a thermocouple.

Description of the supplied thermocouple and transmitter

Learning outcome

After completing this section, you will be able to:

- Describe the specific characteristics of the temperature meter provided with the system.

Temperature control can be crucial in a Three-Phase Separator. Some separators are heated to work efficiently, as higher temperatures generally mean a better emulsion separation. Although the Three-Phase Separator Learning System does not contain heating elements, a measurement of temperature can be made on the process.

The temperature transmitter is a device specifically designed to display the temperature measured by up to two probes (thermocouples and/or RTDs). It uses the HART communication protocol. The transmitter is identified by the tag attached to the housing. For details, please refer to documentation provided by the manufacturer.

The only way to change the configuration of the transmitter is to use the Fieldcare software and a communication protocol via a communication box. Otherwise, the default parameters will need to be used.

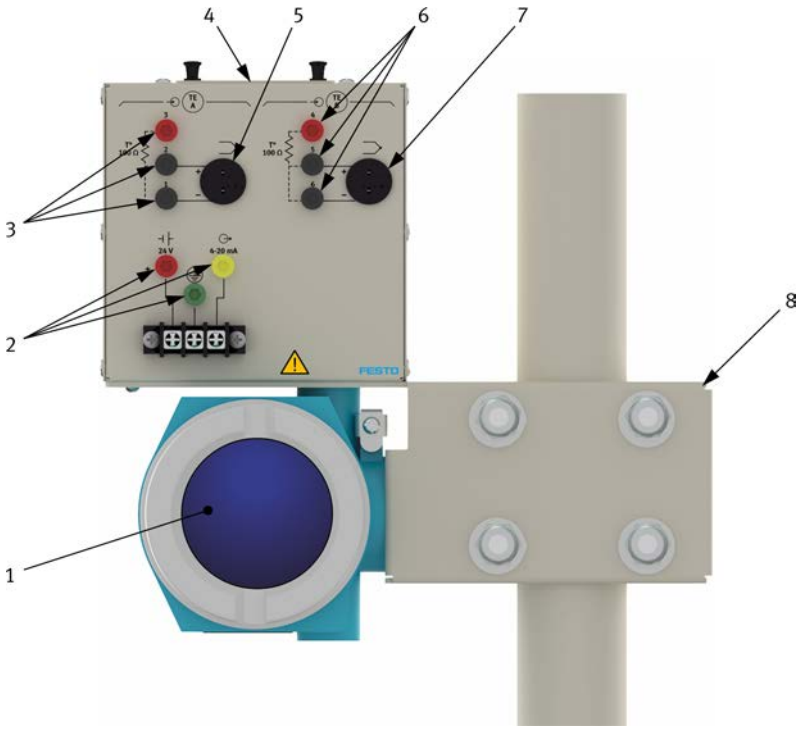

Figure 46: Temperature transmitter.

1. **Display.** The display shows the temperature as measured by the sensor in the units of your choice along with a bargraph. Error codes are also displayed when necessary along with icons indicating whether communication protocols are at work or whether the configuration of the transmitter is locked to prevent editing.

2. **Power input and signal output.** The device requires a 24 V dc signal to operate. The connectors come in two versions based on whether the communication protocol is HART or Fieldbus.

3. **Port A – RTD input.** This series of three jacks allows you to connect an RTD probe to port A of the temperature transmitter.

4. **Fault panel.** Two fault switches are located behind the panel. Your instructor can use these switches to insert a fault on the device. It is a good practice to always make sure the faults are deactivated when investigating a problem with the transmitter.

5. **Port A – thermocouple input.** This connector allows you to connect the two-pronged plug of a thermocouple probe to port A of the temperature transmitter.

6. **Port B – RTD input.** This series of three jacks allows you to connect an RTD probe to port B of the temperature transmitter.

7. **Port B – thermocouple input.** This connector allows you to connect the two-pronged plug of a thermocouple probe to port B of the temperature transmitter.

8. **Mounting bracket.** Used to secure the instrument to the mounting pipe of the process workstation.

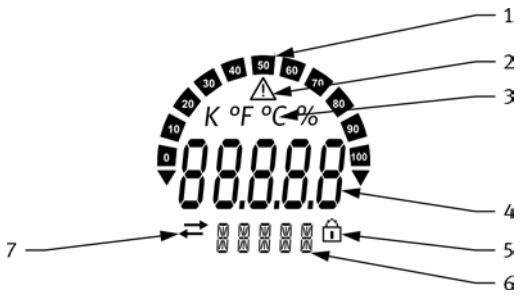

Figure 47: Display of the temperature transmitter.

1. **Bar graph display**. Shows where the measured value is in the measuring range of the instrument, in stages of 10%. The bar graph display flashes when an error occurs.

2. **Caution symbol**. Visible when an error or warning occurs.

3. **Unit display**. Shows the selected unit (K, °C, °F, or %). If another unit is selected (°R, Ohm, or mV), it is visible in the **Status and information display**.

4. **Measured value display**. Display the measured value. In case of an error or warning, the related diagnostic information is indicated.

5. **Configuration locked symbol**. Appears when configuration is locked via the hardware.

6. **Status and information display.** Indicates which value is currently shown. Text can be entered for every value. In case of an error or warning, it indicates which sensor triggered the error/warning.

7. **Communication symbol.** Appears when communication bus is active.

Table 34: Status signal.

Status signal	Meaning
F	**Failure**. A device error is present; the measured value is no longer valid.
C	**Function check**. The device is in service mode, like during a simulation.
S	**Out of specification**. The device is operated outside of its technical specifications (e.g. during a startup or cleaning).
M	**Maintenance required**. The measured value is still valid.

Figure 48: J-type temperature sensor.

1. **Connector.** Insert the connector into the appropriate port of the temperature transmitter to relay the temperature measurement to the transmitter.

2. **Probe rod.** The probe rod conducts the temperature of the process to the thermocouple located inside. The rod must be inserted in the thermowell to be in thermal contact with the process.

3. **T-shaped adapter.** The adapter is designed to be added easily on a process and includes a cavity in which the process fluid flows around a thermowell. The thermowell is glued to the adapter to ensure leak imperviousness.

4. **Thermowell.** The thermowell is a thermal conductor that allows the probe to measure the temperature of the process while protecting the probe from the process. The thermowell is fixed to the T-shaped adapter and no attempt should be made to remove it from the adapter.

Table 35: J-type thermocouple characteristics.

Characteristic	Description
Type	J, grounded junction
Temperature range	0°C to 720°C (32°F to 1330°F)
Physical input measuring range	–20 mV to 100 mV
Precision	Greater of ± 2.2°C and ±0 0.75% (greater of ± 4.0°F and ± 0.75%)
Insertion length	19 cm (7.5 in)
63.2% response time	~15 s (using a thermowell)
Dead time	~4 s (using a thermowell)

Maintenance and Inspection

The present unit provides a list of advice for the maintenance of the Three-Phase Separator Learning System to ensure it stays in good working condition.

It also provides a checklist of elements to look for when performing an inspection of the learning system. A thorough inspection has to be completed before each exercise to validate the good working condition of the Three-Phase Separator Learning System.

Maintenance of the Three-Phase Separator Learning System

It is easy to take care of the learning system and keeping it in a good working condition. Here are some maintenance recommendations:

- Always use the learning system within its operating parameters (pressure, flow rates, levels). Be sure that the system requirements are met.
- Perform a quick inspection of the whole learning system before each use. Read the next section for a checklist of components to inspect.
- Release the pressure in the vessel when the learning system is not in use. Keeping an air pressure inside the vessel can deprime the pumps. It does not cause damage, but pumps will need to be primed before use. Follow the Quick-start guide of the present user guide to prime the pumps.
- Also disconnect the power cable and the pressurized air supply when the system is not in use.
- If the system is not used for a long period (more than a couple of days), purge the vessel to put the water and oil back into the tanks. Follow the purge procedure in a further section of this document.
- Once every year, it is recommended to perform a quick clean-up. Follow these steps:

  1. Purge the vessel to put back oil and water into their respective tanks. Follow the Shutdown and purge procedure of the present user guide.
  2. Empty the water tank and dispose of it according to local regulations. The drains of the tanks are on their bottom, they are accessible on the front of the learning system.
  3. Close the drain and fill the tank with fresh water.

4. Run the system for a couple of minutes feeding only water into the vessel. Wait until the components of the vessel and the water sale line has been rinsed. The use of soap or detergent is not recommended.

5. Purge the rinsing water out of the vessel and dispose of it according to local regulations.

6. Fill the tank with fresh water. Add blue dye if desired.

The system has been cleaned and it is ready to be used again.

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 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.

Inspection checklist

As previously mentioned, an inspection of the Three-Phase Separator Learning System is required each time it is used. It is a good practice to always make sure an equipment is in good condition before starting it. Take a look around the system and try to notice if any component is not in perfect condition. Here is a checklist of possible problems and elements to look for:

- ☐ Damaged, leaky, clogged, loose, or disconnected hoses.
- ☐ Damaged, loose, or disconnected wires.
- ☐ Spills of oil or water, or hissing caused by air leakage.
- ☐ Cracks on the vessel or leaks near its sealed joints.
- ☐ Disassembled or unsecured components that may fall off.
- ☐ Presence of mold or deposits in the vessel. They can cause problem to the separation process. Perform a quick clean-up to remove the undesired content in the vessel.
- ☐ Damage to or misadjustment of the pressure regulators. The one on the left is responsible for the pressure inside the vessel. It should be set at 0.5 bar (7 psi) and secured by a lock. The one on the right provides pressurized air to the pneumatic equipment. It should be set at 1.7 bar (25 psi).

Figure 49: Pressure regulators.

☐ The valve on the side of the back pressure regulator should be open to let air flow through it. The bypass line below it should be closed with the screw below the back pressure regulator.

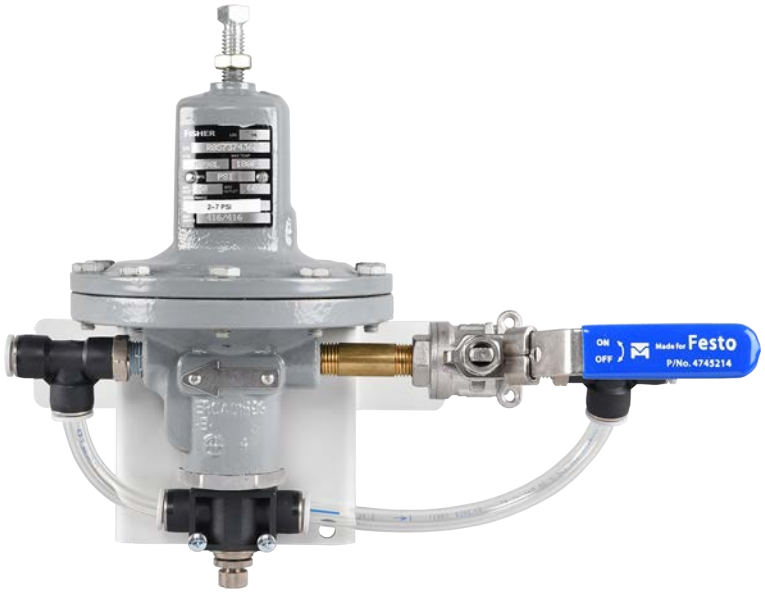

Figure 50: Back pressure regulator.

☐ There are two bypass valves on the sale lines, just below the level control valves (one for water and one for oil). Both should be completely closed.

Figure 51: Flow control valve with bypass.

☐ The separator has an inline mixer to increase the amount of emulsion produced. It should be bypassed by opening the bypass valve and keeping the inline mixer valve closed.

Figure 52: Inline mixer.

☐ All fault valves should be open. They are located on the air hoses near the float and displacer level controllers.

☐ The emergency stop button should not be activated. To restore it to its normal position, turn it counterclockwise.

- ❑ Once the system is turned on, the P1 power indicator on the pump control unit should light up. The screens of the touchpads controlling the pumps should light up as well.
- ❑ (Applicable to instrumentation) Once the system is turned on, all transmitters should boot within a couple of seconds and a measurement should be displayed on their screen, as well as on the screen of the HMI. All fault switches on the connection boxes of the instruments should be turned off.
- ❑ (Applicable to instrumentation) There should not be input failures on the instruments. If such a failure is present, you may need to set the configuration on the transmitter or on the HMI.

This checklist is complete. If all the elements have been inspected correctly, the Three-Phase Separator Learning System should be in perfect condition and ready to be used.

Shutdown and Purge Guide

This unit provides a procedure to adequately shutdown the Three-Phase Separator Training System at the end of a laboratory session. The system should be shutdown when it is not in use, as it should never be left running unattended. This first procedure followed by a purge procedure to empty the vessel of its content.

It is not necessary to empty the vessel after each exercise, especially if the next exercise is performed on the same day as the previous. However, a purge should be performed when the learning system is not used for several days or more.

NOTICE
The verifications listed in the Inspection checklist of the present user guide must have been performed to ensure that the Three-Phase Separator Training System is properly set and in good working condition. Failure to do so could result in damage to the equipment.

Shutdown guide

1. To shutdown the Three-Phase Separator Learning System after the completion of an exercise, set all fluid input flow rates to zero on the rotameter board.

2. Immediately shut down the pumps. Simply press the red "O" button on their setpad.

3. Turn the power switch on the pump control unit.

4. The pressure inside the vessel will eventually come down to atmospheric pressure on its own, but this is a lengthy process. To accelerate it, it is possible to open the bypass valve on the oil sale line (the bottom one). Shut the valve closed when the pressure on the gauge (on top of the vessel) gets close to zero.

The Three-Phase Separator Learning System is now shutdown until the next exercise is performed. If the system is not in use for an extended period of time, follow the purge procedure in the next section.

Purge guide

Learning outcome

After completing this section, you will be able to:

- Perform a safe purge of the Three-Phase Separator Learning System from its content.

This procedure assumes you are already familiar with the operation of the Three-Phase Separator Learning System. Make sure the system is in its normal state and that no fault switch is active.

NOTICE

Take all necessary precautions when performing a purge on the system. Air passing through the turbines for more than a few seconds can cause serious damage. Keep the pressure inside the vessel at a manageable level. Close the bypass valves when no liquid is present in the tubing. This procedure should always be performed in the presence of your instructor.

1. In order to drain the learning system properly, the vessel must still be pressurized. Keep an eye on the pressure inside the vessel; it should be kept around 3-5 kPa. If it gets too low, the purge is a much longer process. You can help by feeding a small flow rate of air (around 15 SLPM) into the vessel. Shut it down before the purge is complete.

2. Set oil feed rate to zero and turn off oil pump. Keep feeding water into the vessel until all the oil reaches over the weir plate into the oil output section. You will need to activate the fault valve that cuts the air supply to the water level control valve to achieve that. Be careful that little to no water reaches the oil section.

3. Deactivate the fault valve of the water level control valve. Set water feed rate to zero and turn off water pump.

4. Open both bypass valves below the two pneumatic control valves by turning the knobs to the left. Valve HV201 allows water (the top one) to drain while valve HV301 (the bottom one) controls the oil output flow.

5. Both water and oil should flow down into the tanks at the bottom of the system. Oil from the separation vessel will flow into the water tank. It is of no consequence as oil floating on top of the tank will drip down into the oil tank. If any water flows into the oil tank, it will get sucked up by the pump the next time the system is in use.

6. As soon as one side of the separator is empty, close the corresponding bypass valve.

7. Monitor the pressure inside the vessel using the pressure gauge at the top of the separator. When the vessel is at atmospheric pressure, close the second bypass valve.

NOTICE

Watch closely as the remainder of the air pressure is purged from the vessel. Air passing through the turbine for more than a few seconds can cause damage to the equipment.

This procedure is now complete. Turn off the system by turning the power switch. You can now safely unplug the electrical cord and the air supply. The residual air pressure, if any, will drain out on its own.

It is common for some oil to get into the water tank. A length of piping is installed between the two tanks to allow the oil to flow back to its own tank. For this to work, the water level should reach the indicated line on the tank.

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