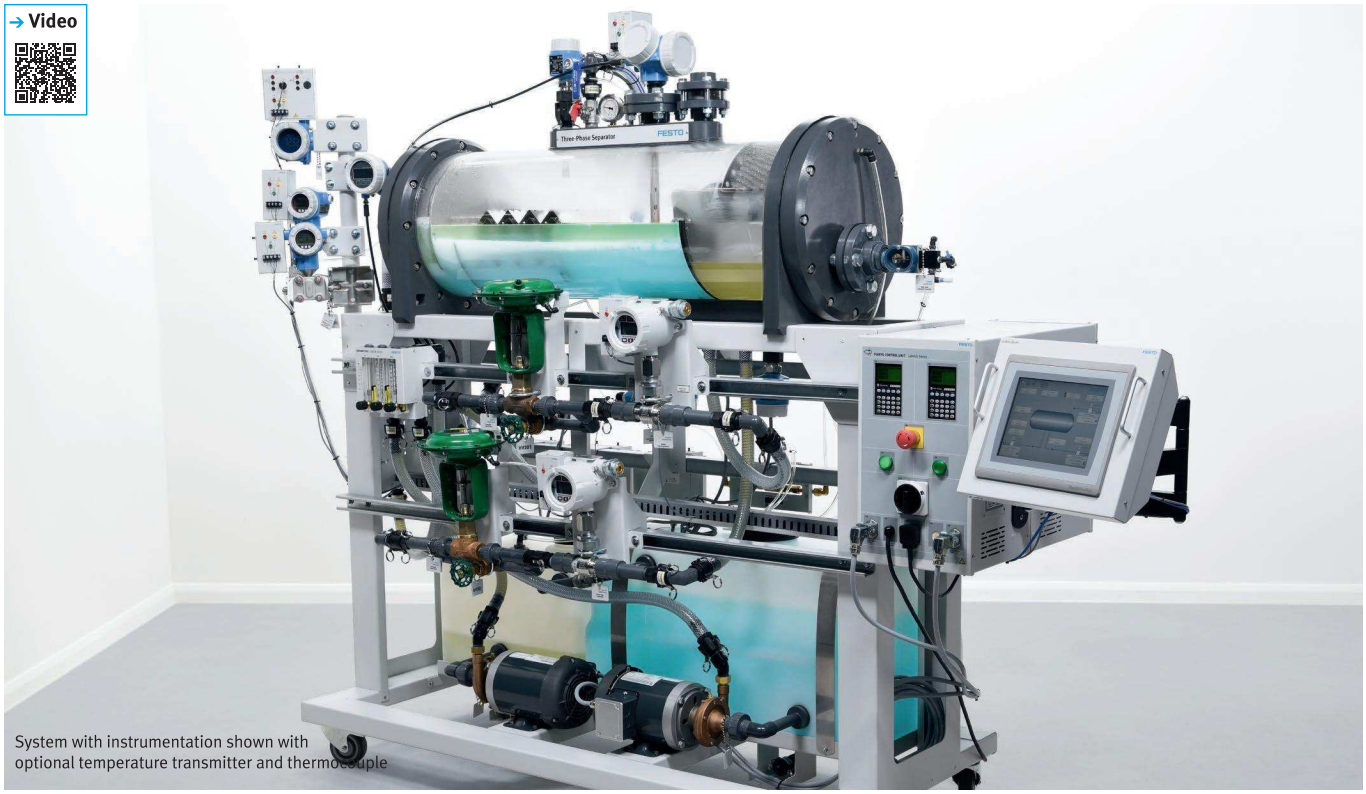
Three-Phase Separator

Practical Training in the Crude Oil Separation Process

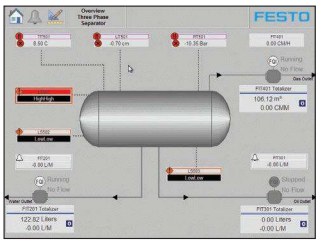
→ Video



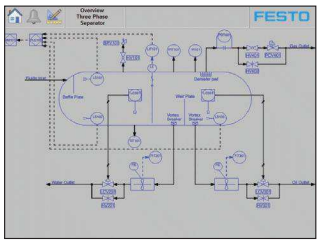
System with instrumentation shown with optional temperature transmitter and thermocouple

Industry-Relevant Skills
The Three-Phase Separator demonstrates the fundamentals of oil separation, such as the effect of gravity, the effect of layer thickness, viscosity, retention time, density difference, vessel pressure, and oil/water/gas ratio.

This helps operators, instrumentation technicians, and process engineers to develop industry-relevant skills for successfully performing operation, troubleshooting, and maintenance tasks in the oil and gas industry.



Observable Flow and Processes
The vessel features standard zones of three-phase separators: inlet, flow distribution, gravity separation, and outlet. An inline mixer emulates crude oil by creating an emulsion with water, air, and oil. The separation process itself then begins.



The large, clear acrylic vessel and clear PVC piping allow for observation of flows and of internal components (diverter plate, perforated baffle plate, coalescing plates, weir plate, demister pad, etc.) during operation. This boosts student understanding of the process itself and the role of each component. Safety is ensured with an industrial pressure relief valve and a rupture disc.



System Configurations
Two configurations are available:
– Three-Phase Separator with basic pneumatic control for training operators;
– Three-Phase Separator with Instrumentation, including smart devices, for training instrumentation technicians as well as process engineers.

It is also possible to upgrade the basic pneumatic control system to a system with instrumentation using the instrumentation add-on.

Festo Didactic is part of the Rockwell Automation Machine Builder Partner Program and has contributed to its University Partnership Program.

For tailored advice and product selection or configuration assistance, please contact a sales representative.

Three-Phase Separator with Basic Pneumatic Control
Three-phase separator workstation with a back pressure valve, a pneumatic float level controller, a pneumatic displacer level controller, a safety pressure valve, and a pneumatic control valve. The Instrumentation add-on can be added.

120 V, 60 Hz	**8094286**
220 – 240 V, 50/60 Hz	**8094287**

Three-Phase Separator with Instrumentation
Three-phase separator workstation with a back pressure valve, a pneumatic float level controller, a pneumatic displacer level controller, a safety pressure valve, an orifice plate (air-high flow), a differential-pressure transmitter (HART, low range), a turbine flow transmitter, a pressure transmitter (HART), a vibrating fork level switch, a multi-parameter guided-radar level transmitter, a pneumatic control valve, and a touch screen graphic terminal (Allen-Bradley).

120 V, 60 Hz	**8094289**
220 – 240 V, 50/60 Hz	**8094290**

Recommended accessories:

Three-phase separator, instrumentation add-on (120 V, 60 Hz)	8094292
Three-phase separator, instrumentation add-on (220 – 240 V, 50 /60 Hz)	8110644
J-type thermocouple	582406
Electromagnetic flow transmitter (HART, transmitter on the right)	582413
Coriolis flow transmitter (HART)	588323
Temperature transmitter (HART)	582422
HART software configurator	588420
Calibration kit	588416
Calibration kit with pressure modules	588417
FactoryTalk View Studio ME → Page 173	

Interactive Measurement and Control Experience
Smart instrumentation is used not only for measurement, but also for optimization of the separation process, which reduces operation cost and maximizes operator and asset safety.

The Three-Phase Separator allows students to perform experiments with measurement devices and control components commonly found in industry. Students get first-hand experience with Rockwell Automation and Endress+Hauser technologies, both of which are used on a large scale in the oil and gas industry.

The system is monitored using PlantPAx, as is usually the case in real world scenarios.

An Allen-Bradley CompactLogix PLC monitors processes. Two Allen-Bradley variable frequency drives allow the user to change operating flow rates, as well as water and oil pressure. Gas flow measurement is possible thanks to a differential pressure transmitter.

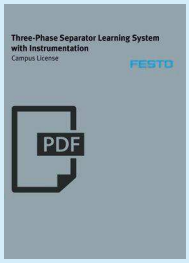
The HMI for data acquisition and alarm management – a large PanelView Plus 7 touch panel – uses the standard PlantPAx library. It also allows for fault insertion during troubleshooting exercises.

Learning Objectives
Basic control system:
– Become familiar with three-phase separation mechanisms and design of separator vessels
– Experiment with the effect of various parameters on separation efficiency
– Adjust pneumatic level controllers
– Configure and operate specific instrumentation used with three-phase separators
– Read piping and instrumentation diagrams
– Practice troubleshooting

Additional objectives with the system with instrumentation:
– Use an HMI and manage alarms efficiently
– Learn about PLCs
– Install and use different types of smart instrumentation
– Get acquainted with the HART communication protocol (optional)

Recommended Learning Material

Workbook



Campus license:

Order no.	8099622

Notes: The campus license is currently offered in English only, but other languages will be added as they become available. Campus licenses include the student and the instructor PDF versions of the workbooks “Three-Phase Separator Basic Control” and “Three-Phase Separator Instrumentation”.

Courses on Festo LX

→ Three-Phase Separator – Basic Control



→ Three-Phase Separator – Instrumentation



Transmitters and Primary Flow Elements

Pressure

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1 **Pressure Transmitter**
Rugged and reliable gauge pressure measurement device for the fluids in the Pressure, Flow, Level, and Temperature Process Learning Systems as well as for the Three-Phase Separator. Available in two versions:

HART	**588333**
Bluetooth, Heartbeat, HART	**611544**

2 **Differential-Pressure Transmitter (Low Range)**
Device designed to operate in a range going from a difference of 0 kPa (0 psi) to an absolute difference of 50 kPa (7.3 psi).

HART	**582410**
Bluetooth, Heartbeat, HART	**611539**
Profibus-PA	**582412**

3 **Differential-Pressure Transmitter (Medium Range)**
Device designed to operate in a range going from a difference of 0 kPa (0 psi) to an absolute difference of 300 kPa (45 psi). It is compatible with the HART communication protocol.

Order no.	**588335**

4 **Differential-Pressure Transmitter (High Range)**
Device designed to operate in a range going from a difference of 0 kPa (0 psi) to an absolute difference of 1.6 MPa (240 psi).

Hart	**582408**
Profibus-PA *	**588318**
Bluetooth, Heartbeat, HART	**611538**

* Can only be used with the PlantPAx demonstrator.

5 **Digital Pressure Gauge**
Device that provides a direct reading of the pressure in one of many convenient measurement units. It features two interconnected pressure ports, an LCD display, and is equipped with a mounting bracket for simple installation on the workstation. Available in two versions: high range (0-100 psi or 0-690 kPa) and low range (0-30 psi or 0-200 kPa).

Low range	**582387**
High range	**588300**

6 **Pressure Switch With Analog Output**
Digital pressure gauge ranging from 0 kPa (0 psi) to 1000 kPa (145 psi). It features a 4-20 mA output signal proportional to a user-defined upper value. A relay can be configured so as to become activated when the measured pressure rises above a threshold value. Recommended learning material, also order: “Pressure and Level Switches” ➔ Page 165

IO-Link	**611537**

Note: An IO-Link master module is required; one is included in the training package TP 1312 Smart Sensors, sold separately ➔ Page 118.

Transmitters and Primary Flow Elements

Flow

1 **Ultrasonic Flow Transmitter**
Device that infers the flow rate by measuring the transit-time differential between an ultrasonic pulse traveling upstream with one traveling downstream. The ultrasonic pulses are emitted by two clamp-on sensors installed on a clear PVC pipe. Recommended learning material, also order: "Ultrasonic Flow Transmitter" ➔ Page 165

Order no.	**588330**

2 **Electromagnetic Flow Transmitter**
Device that relies on the conductive properties of liquids traveling across a magnetic field to measure the flow in a pipe. It is insensitive to vibrations and causes almost no pressure loss. Temperature variations of the fluid are automatically compensated by the device for accurate flow rate measurement. The variant "transmitter on the left" must be used if the transmitter is to be installed on the second team side of the Process Workstation. Recommended learning material, also order: "Electromagnetic Flow Meters" ➔ Page 164

Transmitter on the right

HART	**582413**
Ethernet	**588319**
WLAN, Heartbeat	**611542**

Transmitter on the left

HART	**582419**
Ethernet	**582418**
WLAN, Heartbeat	**8184574**

3 **Paddle Wheel Flow Transmitter**
Device that provides an accurate measurement of the flow rate by inserting a paddle wheel into the flow stream. A sensor measures the velocity of the paddle wheel which is converted into a direct reading of the flow rate displayed on a remote digital display. Also features a 4 – 20 mA output signal. Recommended learning material, also order: "Paddle Wheel Flow Transmitter" ➔ Page 165

Order no.	**588326**

4 **Vortex Flow Transmitter**
Device that uses the dynamic properties of fluids to create small vortexes whose frequency of detection is proportional to the flow in a pipe. This device is typically used in the industry to measure the flow of high or low temperature fluids. Recommended learning material, sold separately: "Vortex Flow Transmitter" ➔ Page 164

Hart	**588320**
Hart, Heartbeat	**611543**

5 **Coriolis Flow Transmitter**
Flow measurement device that uses the Coriolis forces generated when a fluid goes through the flow meter to measure the mass flow of liquid in a pipe. Since it measures the mass flow, the measurement is not affected by changes in the temperature, viscosity, and density of the fluid. Recommended learning material, also order: "Coriolis Flow Transmitter" ➔ Page 164

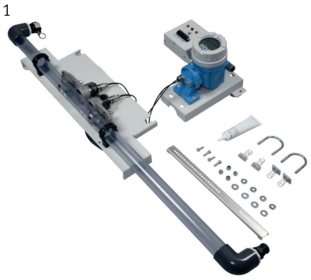
HART	**588323**
WLAN, Heartbeat	**611540**

6 **Pitot Tube**
Flow measurement device relying on a small tube inserted in the flow stream to measure the dynamic pressure of a fluid from which the flow rate can be inferred. It presents a low pressure-loss and clearly illustrates the working principles of such a device. It requires the use of a differential-pressure transmitter to transform the pressure drop into a usable flowrate value. Recommended learning material, also order: "Flow Primary Elements" ➔ Page 163

Order no.	**588316**

7 **Picomag Electromagnetic Flow Meter**
Magnetic-inductive flow meter Picomag. Operation and maintenance via the SmartBlue app. Recommended learning material, also order: "Electromagnetic Flow Meters" ➔ Page 164

Bluetooth, IO-Link	**611547**

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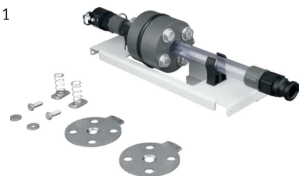

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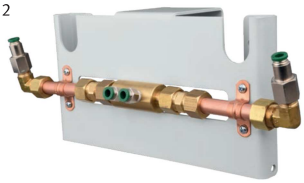

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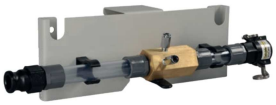

7


Transmitters and Primary Flow Elements

Flow, Level

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1 **Orifice Plate**
Flow measurement device using the Venturi effect to produce a pressure drop from which the flow rate can be inferred. This primary element consists of a thin metal plate with a sharp-edged upstream aperture (orifice) inserted between two flanges at the location where the flow must be determined. β ratio: 0.55, 0.65, 0.75. Provided with three different plates. It requires the use of a differential-pressure transmitter to transform the pressure drop into a usable flow rate value.

Order no. **588315**

2 **Orifice Plate (Air)**
Flow measurement device designed for air applications. It uses the Venturi effect to produce a pressure drop from which the flow rate can be inferred. This primary element consists of an orifice precisely machined in a brass tube. It requires the use of a differential-pressure transmitter to directly convert the pressure drop into a usable flow rate value.

Order no. **582404**

3 **Venturi Tube**
Flow measurement device that relies on the Venturi effect to produce a pressure drop from which the flow rate can be inferred. This apparatus provides a clear picture of the phenomena and offers a low permanent pressure-loss. It requires the use of a differential-pressure transmitter to transform the pressure drop into a usable flow.

Order no. **582403**

4 **Rotameter**
Variable area flow meter calibrated to measure the flow of water in the process loop. It provides a direct visual reading of the flow rate by observing the position of the float inside the transparent graduated tube.

Order no. **582402**

5 **Rotameter (Air)**
Variable area flow meter specifically calibrated to measure the air flow in a compressed air setup. It provides a direct visual reading of the flow by simply observing the position of a float inside the transparent graduated tube.

Order no. **582405**

6 **Conductivity Level Switch**
Level limit switch made of three probe rods of different lengths. When two of the probe rods come in contact with the conductive liquid, a measurable current flows between the two rods which allows the student to detect that a certain level has been reached. The three-rod configuration allows the detection and the monitoring of a low and a high level of liquid in the column of the Pressure, Flow, Level, and Temperature Process Learning Systems. With two output relays. Recommended learning material, also order: “Pressure and Level Switches” → Page 165

Order no. **588346**

7 **Float Switch**
Level limit switch triggered when a float is raised by buoyancy forces as the level of liquid in the column reaches the float. The device has one contact which can be configured to be either normally closed or normally open. Its length can also be adjusted to accommodate the detection of different levels. Recommended learning material, also order: “Pressure and Level Switches” → Page 165

Order no. **588348**

1 **Ultrasonic Level Transmitter**
Measurement device that uses sound waves to detect the level of liquid in the column of the Pressure, Flow, Level, and Temperature Process Learning Systems. This transmitter includes an ultrasonic sensor/emitter installed on the flange of the column and a transmitter supporting the HART communication protocol. The device can be configured manually, but it is strongly recommended to use an optional Software Configurator. Recommended learning material, also order: "Ultrasonic Level Transmitter (HART)" → Page 165

Order no.	**588337**

2 **Guided-Radar Level Transmitter**
Measurement device that uses electromagnetic waves to detect the level of liquid in the column of the Pressure, Flow, Level, and Temperature Process Learning Systems. Changes in the density, conductivity, and composition of the process fluid do not affect this sensor. This transmitter includes a rod probe to guide the signal in the column and a transmitter. It can be configured manually via its alphanumeric display and push-buttons, a software configurator is required to efficiently program advanced functions. Recommended learning material, also order: "Radar Level Transmitters" → Page 166

Hart*	**589127**
Bluetooth, Heartbeat, HART	**611545**

* Software configurator required
→ Page 101

3 **Radar Level Transmitter**
Device that uses electromagnetic waves to detect the level of liquid in the column of the Pressure, Flow, Level, and Temperature Process Learning Systems. It includes a horn antenna to direct the signal and a transmitter. It can be configured manually via its alphanumeric display and push-buttons, a software configurator is required to efficiently program advanced functions.

HART*	**589125**
Bluetooth, Heartbeat, HART	**589125**

* Software configurator required
→ Page 101

4 **Capacitive Level Transmitter**
Level measurement device based on the change in the capacitance of a capacitor as the level of fluid constituting the capacitor varies. It includes a 4–20 mA output to monitor the level in the column and is compatible with the HART communication protocol. The device can also be configured manually via its alphanumeric display and push-buttons. Recommended learning material, also order: "Capacitive Level Transmitter" → Page 165

Order no.	**588350**

5 **Vibrating Fork Level Switch**
Level limit switch that detects whether or not the level of water in the column has reached a set level. The fork of the switch is continuously excited at its natural resonance frequency. When the level of liquid reaches the fork, the frequency of oscillation changes. This is detected by the device which triggers a relay. The device allows continuous monitoring and is suitable for overspill-protection setups. Recommended learning material, also order: "Pressure and Level Switches" → Page 165

Order no.	**588344**

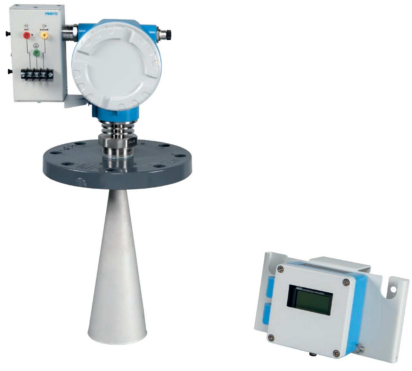
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Transmitters and Primary Flow Elements

pH, Conductivity, Temperature, Heat Exchangers

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1 **Temperature Transmitter**
Device that displays the temperature measured by up to two devices such as RTDs or thermocouples. It also outputs either a 4-20 mA signal compatible with the HART communication protocol. The configuration of this transmitter can only be modified using a software configurator.

Order no. **582422**

2 **Platinum RTD 100**
Resistive thermal device which uses the change of electrical resistance of platinum with changing temperature to determine the temperature. The model is provided with a T-shaped connector and a thermowell for inclusion in the process loop.

Order no. **582407**

3 **J-Type Thermocouple**
Device that uses the thermoelectric effect to perform precise measurement of temperature. The model is provided with a T-shaped connector and a thermowell for inclusion in the process loop.

Order no. **582406**

4 **Brazed Plate Heat Exchanger**
Compact type of exchanger made of a series of thin, usually corrugated plates which create cavities in which the process fluids flow. Each plate has four corner ports (one inlet, and one outlet for each of the two fluids). When the plates are assembled, the ports line up to give access to the cavities. For each cavity, a pair of gaskets or restrictions alternately blocks the access to one of the two fluids and lets the other one flow from the inlet to the outlet.

Order no. **582400**

5 **Gasketed Plate Heat Exchanger**
Device that features a series of thin, thermally conductive plates that create cavities or channels for the two fluids. By alternating the fluid that circulates in each channel between fluids 1 and 2, a multi-layered and compact structure is created and allows an efficient heat transfer to take place. Plates can be added or removed to change the surface area of the where the heat exchange takes place.

Order no. **588309**

1/2 **Shell and Tube Heat Exchanger**
Made of a series of tubes around which a watertight shell is built. A given fluid flows in the tubes while another one flows in the shell around the tubes.

1 1-pass	**588310**
2 4-pass	**588311**

3 **pH Transmitter (HART)**
Features a one-channel Liquiline M CM42 transmitter from Endress+Hauser for pH, conductivity or oxygen measurement. A pH probe measures the electrochemical potential of a solution to determine its pH. The device displays the pH measured by the probe and has a 4-20 mA output to transmit the measurement to a controller. It uses the HART protocol, 4–20 mA.

Order no.	**588353**

4 **pH Transmitter (HART)**
Features a 4-channel Liquiline CM444 transmitter from Endress + Hauser for pH, ORP, conductivity, oxygen, chlorine, turbidity, and sludge level measurement, and more. It uses the HART protocol, 4–20 mA.

Heartbeat	**611546**

5 **Conductivity Transmitter**
Device that features a probe which measures the conductivity of a solution. The probe has a large measurement range and a high durability. The device displays the conductivity measured by the probe and has an output to transmit the measurement to a controller. Supports the HART protocol.

Order no.	**588355**

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Valves

Pressure, Flow, Level, Temperature, Air

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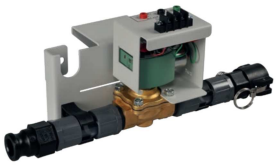
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1 **Pneumatic Control Valve**
Industrial bronze control globe valve of the equal percentage type and is normally open. It includes a current-to-pressure converter which transforms a 4-20 mA input signal into a pneumatic output signal sent to the actuator of the control valve. Recommended learning material, also order: “Control Valves” → Page 163

Order no.	**582424**

2 **Electric Control Valve**
Industrial bronze control globe valve of the equal percentage type and is normally open. This device transforms a 4-20 mA input signal directly into a specific opening of the control valve. A 0-10 V dc output is used as a feedback signal to monitor the position of the valve.

Order no.	**588360**

3 **Pneumatic Control Valve with Digital Positioner**
Industrial bronze control globe valve of the equal percentage type and is normally open. It includes a digital valve controller which transforms a 4-20 mA input signal into a pneumatic output signal sent to the actuator of the control valve. The controller has a high-performance positioner. Recommended learning material, also order: “Control Valves” → Page 163

HART, DVC 2000	**588357**
HART, DVC 6200	**588363**

4 **Pneumatic Control Valve (with Positioner, Fisher 3660)**
Industrial bronze control globe valve of the equal percentage type and is normally open. It includes a current-to-pressure converter which transforms a 4-20 mA input signal into a pneumatic output signal sent to the actuator of the control valve. A pneumatic positioner provides a valve position proportional to the pneumatic signal. Recommended learning material, also order: “Control Valves” → Page 163

Order no.	**588358**

5 **Solenoid Valve**
A simple unidirectional, direct-acting, normally closed valve made of brass which can be used to effect on/off control on a process. It is fully open when a 24 V dc signal is applied to the electrical connectors wired to the solenoid.

Order no.	**582426**

6 **Ball Valve**
Device used for on/off control of ports in the Pressure, Flow, Level, and Temperature Process Learning Systems. It can also be used to throttle and manually regulate the flow in a process loop.

Order no.	**588365**

7 **Three-Way Pneumatic Control Valve**
Industrial bronze control globe valve of the equal-percentage type designed to be used in mixing mode (two inlets, one outlet). Normally open on the lower port.

Pneumatic control	**582430**
Positioner (Fisher 3660)	**588373**
With dig. pos. (HART) DVC 6200	**588376**
With dig. pos. (HART) DVC 2000	**588372**

Pneumatic Control Valve (Air)
Normally closed stainless steel valve with 1/4 inch connectors. It features a rugged construction and good control characteristics over the air flow. It includes a current-to-pressure converter which transforms a 4-20 mA input signal into a pneumatic signal sent to the actuator of the valve.

8 Pneumatic control	**582428**
Positioner (Fisher 3660)	**588367**
HART, with dig. pos. DVC 6200	**588368**

9 **Muffler Assembly**
Device composed of two air inlet ports connected to a muffler to reduce exhaust noise. A graduated hand valve for each air inlet restricts the access to the muffler while a third one is used to link the two input lines.

Order no.	**588314**

Components
Calibrators, Configurators

1 **Calibration Kit**
This kit includes the equipment required to precisely adjust the control valves and to perform diagnostic tests on electrical devices. The kit contains a Fluke 725 multifunction process calibrator which can act as a source and measure different parameters. A calibration pump completes the kit and is used to calibrate pressure devices.

Order no.	**588416**

Calibration Kit with Pressure Modules
This kit is a variant of the Calibration Kit that also includes a Fluke 725 multifunction process calibrator and pressure modules (a test pump and two pressure gauges) for reliable measurement of pressure directly on the Fluke calibrator.

Order no.	**588417**

2 **Calibration Kit (HART)**
This kit includes the equipment required to precisely adjust the control valves, perform diagnostic tests, and interface with smart devices. It contains a Fluke 754 documenting process calibrator with HART capabilities to calibrate, maintain, and troubleshoot HART devices. The Fluke calibrator acts as a source and measures pressure, temperature, and electrical signals. It also include a test pump used to generate a wide range of pressures from vacuums at -95 kPa (-13.9 psi) to pressures up to 410 kPa (600 psi). Two pressure gauges, a low-range version (up to 34 kPa (5 psi)) and a high-range version (up to 690 kPa (100 psi)), are included and can be used with the Fluke calibrator for direct measurement of pressure. Recommended learning material, also order: “Device Configuration (HART)” → Page 167

Order no.	**588418**

3 **Calibration Kit (HART and FOUNDATION Fieldbus)**
This kit includes the equipment required to precisely adjust the control valves, perform diagnostic tests, and interface with smart devices. This version of the kit is compatible with both HART and FOUNDATION Fieldbus. It includes the Emerson AMS Trex™Device Communicator: a universal HART and FOUNDATION Fieldbus communicator. The kit also contains a Fluke 725 multifunction process calibrator which can act as a source and measure different parameters. It also include a test pump used to generate a wide range of pressures from vacuums at -95 kPa (-13.9 psi) to pressures up to 410 kPa (600 psi). Two pressure gauges, a low-range version (up to 34 kPa (5 psi)) and a high-range version (up to 690 kPa (100 psi)), are included and can be used with the Fluke calibrator for direct measurement of pressure. Recommended learning material, also order: “Device Configuration (HART)” → Page 167

Order no.	**588419**

4 **Software Configurators**
The Software Configurators include the FieldCare software necessary to interpret the data related to the different smart devices and to configure their parameters. The HART versions also include a communication box for data transfer between a HART device and a PC with a USB port, while the FOUNDATION Fieldbus version makes use of the FOUNDATION Fieldbus Bridge.

HART	**588420**
FOUNDATION Fieldbus	**588421**
HART/FOUNDATION Fieldbus	**588422**

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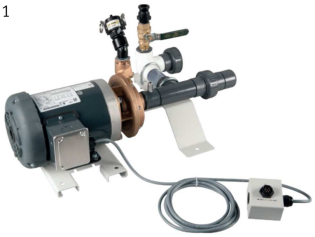
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Components

Pumps, VFDs, Heating, Cooling, Compressors

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1 **Second Pump Add-On**
Additional pump to be used by a second team or to drain a Process Column in advanced control experiments. It requires an AC VFD (EtherNet/IP or PROFINET). This model includes the tubing and equipment required to install the pump on the Process Workstation and to connect it to the system.

Order no.	**582396**

2 **Pumps Add-On (Temperature)**
Two additional pumps used to circulate the warm and cold water to the Heating/Cooling Unit while performing temperature process experiments. Each pump requires an AC VFD (EtherNet/IP or PROFINET). The kit includes the tubing and equipment required to install the pumps on the Process Workstation and to connect them to the system.

Order no.	**582396**

3 **Metering Pump**
Devices that dispenses chemicals to the process at an adjustable and precise rate. It features an LCD, a stroke length adjustment knob and a six-button touch pad. The pump can operate in a fixed rate mode or it can be commanded by an external 4-20 mA signal. A contact relay is also featured.

120 V, 60 Hz	**588377**
220 – 240 V, 50/60 Hz	**588378**

4 **Heating/Cooling Unit**
Unit that warms the contents of one of the two water tanks of the Process Workstation while it cools the contents of the other one. This creates and maintains the temperature differential required for heat transfer experiments. Designed with enough capacity to ensure efficient and continuous operation. Typical capacity: 2 tons, 24000 BTU/hour, or 7 kW.

120 V, 60 Hz	**763447**
220 V, 50/60 Hz	**582401**

5 **GFCI Electrical Distribution Box**
Designed to power the metering pumps. Features an added electrical protection (ground fault interrupter) and four power outlets.

120 V, 60 Hz	**588439**
220 V, 50 Hz	**763515**

6 **AC Variable Frequency Drive (EtherNet/IP)**
Comprises an industrial Allen-Bradley Power Flex 525 1.0-HP AC Drive that controls the pump(s) of the system. It features control inputs and outputs and can optionally communicate via an Ethernet link. The three-phase drive requires a GFCI Electrical Distribution Box.

Single-phase power	**8122680**
Three-phase power	**8122682**

7 **AC Variable Frequency Drive – Single-Phase AC Supply (PROFINET)**
Comprises an industrial Siemens G120 1.0-HP AC Drive used to control the pump(s) of the system. It features control inputs and outputs and can optionally communicate via a PROFINET link. Four switches allow the instructors to insert faults for troubleshooting exercises.

120 V, 60 Hz	**589673**
220 – 240 V, 50/60 Hz	**592685**

8 **Compressor**
Quiet device that provides compressed air to different components. A conditioning unit must be connected to the compressor for certain applications. Available in different variants depending on ac power network voltages and frequencies.

120 V, 60 Hz	**588108**
Other	**On request**

Components
Monitoring

1 **Distributed I/O Module (HART)**
Interface module ET200M from Siemens. Allows the connection of analog I/Os using HART communication protocol to a Siemens PLC through PROFINET communication. Features eight 4-20 mA HART analog inputs and eight 4-20 mA HART analog outputs. With six fault insertion switches.
Order no. **589674**

2 **Emergency Switch Station**
Mushroom-type push-button that opens its circuit when the button is pressed in order to cut the power to some of the 24 V dc outputs of the electrical unit, the pneumatic unit, and the pump drive.
Order no. **582352**

Indicator-Light/Push-Button Station
Three industrial push-buttons, one normally closed and two normally open, to operate the Pressure, Flow, Level, and Temperature Process Learning Systems. With three indicator lights. Operates at a voltage of 24 V DC.
Order no. **587871**

3 **Process Control Signal Tower**
Three lights providing visual signals for various states of the pressure, flow, level, and temperature processes. Lights are stacked one upon another, up to five modules. Each module is easily programmable without any special wiring or tools.
Order no. **587869**

4 **Energy Manager**
Device that records the temperatures measured at different points in the system. It can use the flow rate signals coming from optional transmitters to calculate energy balances in real time. It features an alphanumeric display with eight buttons and is powered by a 24 V dc signal. Up to four Platinum RTDs (Model 46917) can be connected to the inputs of the Energy Manager. Output relays and 4-20 mA outputs are also part of the device. The device can be programmed using a computer and a serial cable.
Order no. **582435**

5 **Deionization Unit**
Designed to filter the process fluid and capture the ions it contains. Composed of two cartridge holders and their associated filters. The prefilter cartridge contains a filter which removes many impurities from the water. The deionization cartridge captures ions from the fluid in its resin.
Order no. **588437**

6 **Water Analyzer**
Multifunction device which allows the simple and accurate measurement of the pH, conductivity, resistivity, oxidation reduction potential, total dissolved solids and Langelier saturation index of a test solution.
Order no. **588424**

7 **Paperless Recorder**
Device that acquires, displays, records, and archives analog input signals. Four high-speed 4-20 mA inputs with a scan time of 100 ms can be displayed on the thin-film-transistor (TFT) 17.8 cm (7 in) color display. It can be configured using push-buttons and a shuttle dial, and it can be programmed to activate one of four output relays. Data can be recorded in the internal memory or transferred to a USB stick. An Ethernet port enables recorder integration into a PC network (TCP/IP).
Order no. **595185**

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Components
Workstations

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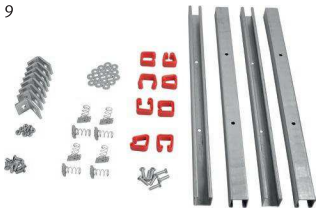

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Back side

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P/F/L/T

1 Process Workstation (Temperature, Pressure, Flow, and Level)
Features two 60 L (16 gal) tanks and four centrifugal pumps. Designed for performing experiments with temperature, pressure, flow, and level processes. Delivered partly-assembled.

Order no.	**582388**

2 Process Workstation (Pressure, Flow, and Level)
Features two 60 L (16 gal) tanks and four centrifugal pumps. Designed for pressure, flow, and level processes, but can be upgraded for temperature processes. Delivered partly-assembled.

Order no.	**582388**

3 Process Workstation
Features a tank and a centrifugal pump. Delivered partly-assembled. Designed for pH/conductivity or air pressure/flow processes.

Order no.	**588302**

Instrumentation Workstation (Without Heating/Cooling Unit)
Houses the Electrical and Pneumatic Units and other electrical components. Can be linked to a Process Workstation with a hitch mechanism, part of the Piping and Accessories Kit.

4 Without Heating/Cooling Unit

Partly assembled	**582393**
Fully assembled	**588306**

5 With Heating/Cooling Unit

Order no.	**582391**

6 Storage Station
Stores up to four flange tops, many flow meters and control valves on six galvanized struts, a few devices on two instrumentation mounting pipes, and various pieces of equipment in the three stainless-steel storage boxes.

Order no.	**588301**

7 Instrumentation Mounting Pipe
Vertical pipe used to install instruments at the appropriate height and close to the point of measurement. Can be mounted on both sides of the workstations.

Order no.	**582444**

8 Drip Tray
Large painted stainless steel drip tray to collect the water. Hand valves and a drain tube included with associated parts.

Front side	**582447**
Back side	**582448**

9 Process Supports (pH)
Package that contains various process struts, a long wire duct, a hose storage rack, and more.

Order no.	**588428**

Package that avoids equipment redundancy if the pH and Conductivity Process Learning System is acquired as an add-on to a Process, Flow, Level, and Temperature Process Learning System.

Order no.	**588426**

10 Process Supports
Packages containing a subset of the following elements: process struts, a storage rack to store up to four optional flange tops, a long wire duct, a hose storage rack, and other assorted items. Designed to address the possibility of two teams sharing the same station and to prevent equipment redundancy.

P/F/L/T	**582445**
Temperature	582446
P/F/L	**588425**
P/F/L (second team)	**588427**

Notes about workstations:
– Most workstations are double-sided to allow two teams of two students to work at the same time, one team on each side.
– Steel frames ensure reliability and durability.
– All are equipped with lockable casters for mobility.

Components

Air and Electrical Supply, Columns, Tanks

1/2 **Column**
Watertight process column made of clear acrylic plastic. Three ports at the top and bottom of the column can be connected to the process loop or sealed off with a cap. A ruler allows simple visual level measurements. Pressure ports allow for the measurement of the pressure at the bottom and at the top of the column. A safety valve prevents the pressure from exceeding a safe limit. The column features an industrial flange that can house an optional level sensors and it contains a stainless steel baffle plate to reduce turbulence at the bottom water intake. Equipped with a bubbler tube to infer the level of fluid in the column. The large-diameter column has a capacity of 30.4 liters (8.0 gal).The small-diameter column has a capacity of 7.6 liters (2.0 gal) and can be used to create interacting second-order processes when connected to the large-diameter column.

1 Large diameter	**582394**
2 Small diameter	**582395**

3 **Upper Tank**
Tank made of heavy-duty polyethylene that is used to create non-interacting second-order processes and is designed to be installed on the top of the Process Workstation. It features five connection ports. It can be used by a single team of students at a time.

Order no.	**588307**

4 **Chemical Tank**
Rectangular carboy designed to contain solutions and dispense chemicals to the process. It is equipped with dripless, quick connectors, a check valve and a faucet.

Order no.	**588436**

5 **Air Tank (Small)**
Robust pressure vessel designed to contain pressurized air. It features two pressure ports each equipped with a quick-connect fitting (1/4 inch) and a graduated hand-operated valve. The tank is coated to resist corrosion and is tested to SAE J10 compliance.

Order no.	**588313**

6 **Air Tank (Large)**
Robust ASME-compliant pressure vessel designed to contain pressurized air. It features two pressure ports equipped with a quick-connect fitting (1/4 inch) and a graduated hand-operated valve.

Order no.	**588312**

7 **Electrical Unit**
Module that features a lockable safety switch, a power transformer from line level to 24 V dc, and all the necessary inputs and outputs in both a safety cable version and in a terminal block version.

120 V, 60 Hz	**592680**
220 – 240 V, 50 – 60 Hz	**592681**

8 **Pneumatic Unit**
Module that features an activation switch to quickly turn on or off the air supplied, an adjustable low-range pressure regulator (0 to 200 kPa (0 to 30 psi)) with its output air port, and an adjustable high-range pressure regulator (0 to 700 kPa (0 to 100 psi)) with its output air port.

Order no.	**582433**

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Components

Piping, Accessories, Consumables

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1 **Piping and Accessories (pH)**
Kit that contains many of the components needed to perform the exercises in the pH and Conductivity Process Training System. It includes an Allen-Bradley or Siemens unmanaged switch.

Allen-Bradley	**588435**
Siemens	**589881**

2 **Piping and Accessories Add-On (pH)**
Kit that contains many of the components needed to perform the exercises in the pH and Conductivity Process Training System. It avoids redundancy of equipment if the pH and Conductivity Process Training System is acquired as an add-on to a Pressure, Flow, Level, and Temperature Process Training System.

Order no.	**588434**

3 **Piping and Accessories (Air)**
This kit includes a reel of tubing, a tube cutter, connectors, and other items required to use the air workstation. A manual needle valve is included to control the flow of air in the process. It includes an Allen-Bradley or Siemens unmanaged switch.

Siemens	**589882**
Allen-Bradley	**588433**

4 **Piping and Accessories (Air)**
This kit is designed to be used with the Air Pressure and Flow Process Add-On. It includes a reel of tubing, a tube cutter, connectors, and other items required to use the air workstation. A manual needle valve is also included to control the flow of air in the process.

Order no.	**588430**

Piping and Accessories
Packages that contain the components required to operate the Pressure, Flow, Level, and Temperature Process Training Systems and to perform the suggested experiments: hoses, elbows, and pressure ports, a wet leg, a three-valve manifold, a small ladder, wires, pressure tubes, tools, and an attach bracket to link the Instrumentation Workstation to the Process Workstation. The variants are designed to allow two teams on the same station while avoiding equipment duplication.

5 Second team	**588429**
Temperature, basic system	**582449**
P/F/L, basic system, A-B	**582451**
P/F/L, basic system, Siemens	**592689**
Temperature, add-on	**588431**

Accessories, Temperature (Advanced)
Includes an infrared thermometer.

Order no.	**582450**

Piping and Accessories, Advanced
Includes the short hose and a three-valve manifold required for some of the advanced experiments on process control.

Order no.	**588432**

Components

Spare Parts Kits, Consumables

Spare Parts Kit 1 for 3531 systems
Set of spare parts for the pH and Conductivity Process Training System.
Order no. **763511**

Spare Parts Kit 1 for 3532 systems
Set of spare parts for the pH and Conductivity Process Training System.
Order no. **763512**

Spare Parts Kit 2 for 3532 systems
Second set of spare parts for the pH and Conductivity Process Training System.
Order no. **763513**

1 **Spare Parts Kit for 3533 systems**
Set of spare parts for the Air Pressure and Flow Process Training Systems.
Order no. **589882**

2 **Consumables Kit 1 for 3532 (pH) systems**
Contains a supply of chemicals (acids, bases, buffers, marker, etc.) required to perform pH experiments using the pH and Conductivity Process Training Systems. It also includes the associated Material Safety Data Sheets (MSDS), a box of plastic gloves, and 1 oz. plastic cups.
Order no. **588438**

3 **Consumables Kit 2 for 3532 systems (Conductivity)**
Includes the consumables required to perform conductivity experiments using the pH and Conductivity Process Training Systems. It includes distilled water, iodized table salt (NaCl) and a conductivity calibration solution.
Order no. **763510**

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