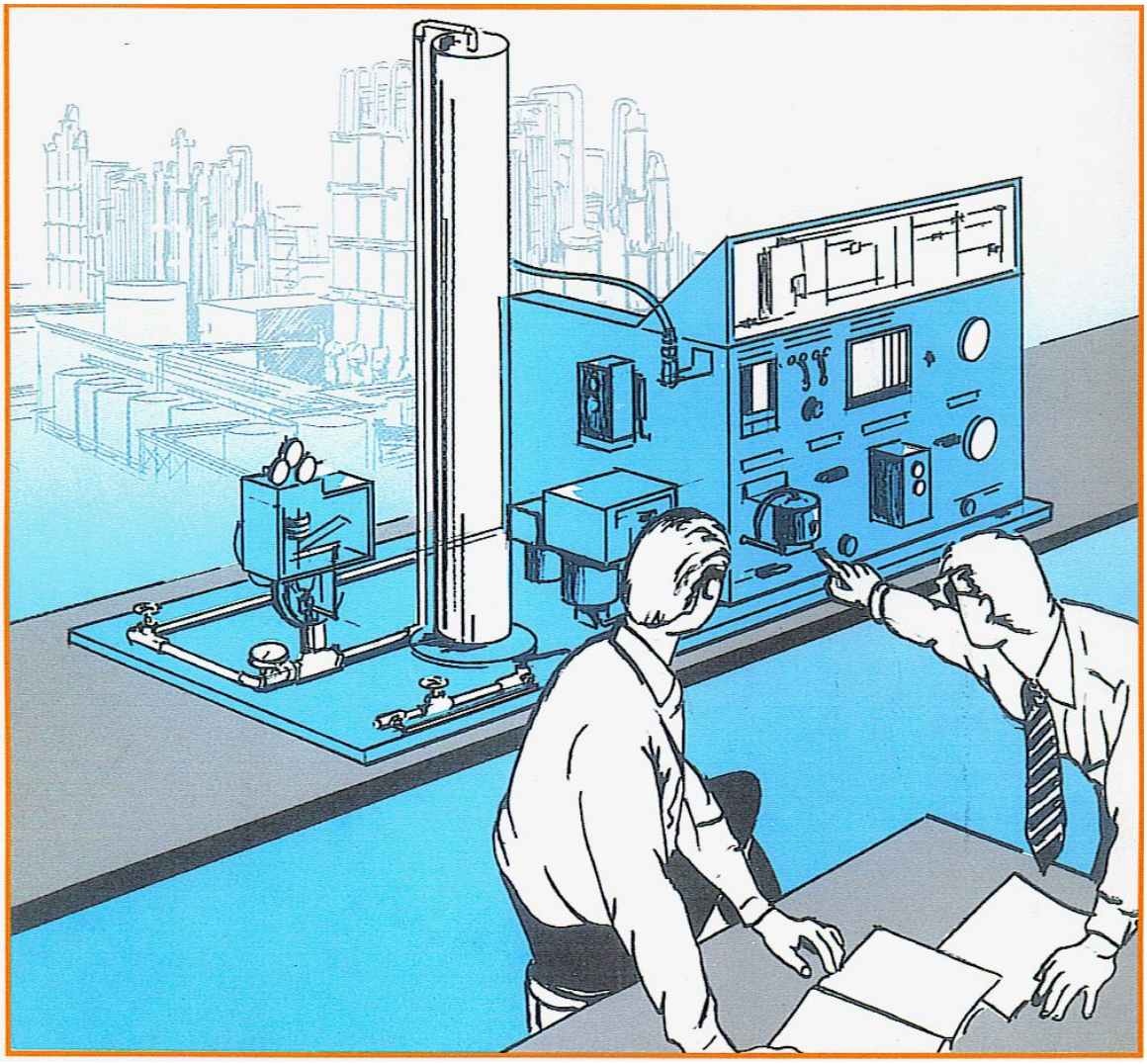
# COMPREHENSIVE INSTRUMENTATION AND PROCESS CONTROL TRAINING

## *Instrumentation Technology*

## *NQF Level 2, 3 & 4*

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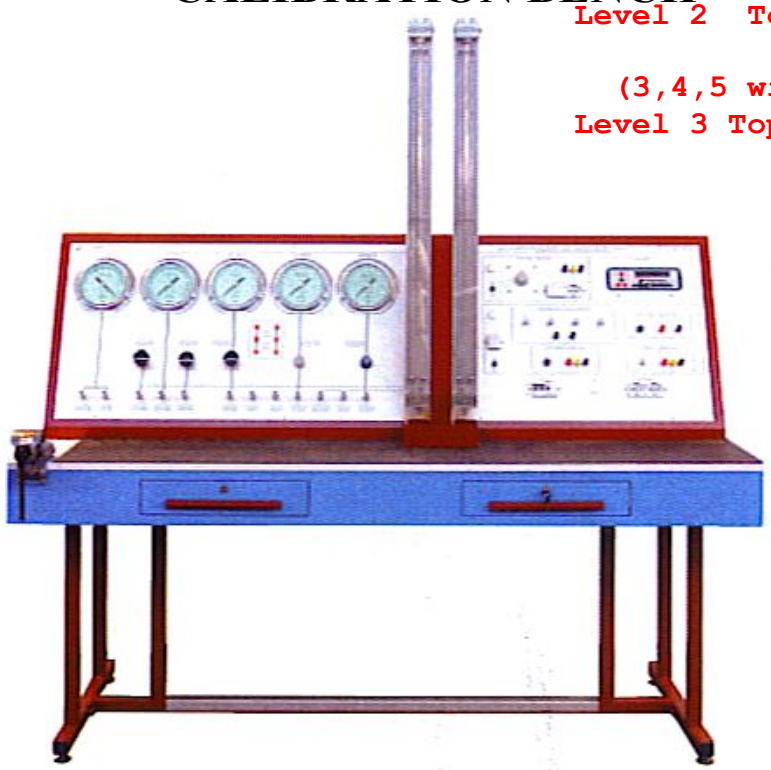
# ELECTRICAL ELECTRONIC & PNEUMATIC CALIBRATION BENCH

**Level 2 Topic 1 Outcome 1 and 2 (3,4,5 with optionals)**
**Level 3 Topic 1 Outcome 1 & 2**
**Topic 4 Outcome 3**



## General

The equipment consists of a bench, a console and a set of instruments, designed to give the learner full exposure in the maintenance and calibration of the pneumatic and electronic instrumentation which form the basis of process control.

## Training Program

The equipment provides practical experience in calibrating

- Pressure gauges
- Pressure switches
- Thermostats
- Pneumatic differential pressure transmitters
- Electronic differential pressure transmitters
- Pneumatic pressure transmitters
- Electronic pressure transmitters
- Pneumatic indicators
- Electronic indicators
- Electronic indicators/controllers
- Pneumatic level transmitters
- Electronic level transmitters
- Pneumatic recorders
- Electronic recorders
- Pneumatic indicators controllers
- Hydrostatic thrust level transmitters
- Capacitive probe level transmitters
- Pneumatic valves
- Positioners

## Services

220/240V L plus ground
Air supply 10bars max

## Technical Specification

Painted carbon steel structure
4 precision pressure gauges, -1 - 0, 0 - 1.6, 0 - 4 and 0-10, class 0.25%
1 manual control station, complete with precision pressure gauge
3 precision pressure reducers
12 pressure outputs
2 differential pressure glass manometers, height = 1000 mm, stainless steel sleeve
Digital multimeter, accuracy ±0.03%, current range 20 A, voltage range 1200 V
Signal generator: 4 - 20 mA
Power supply: 12-24-48 V d.c.
Voltage control: 0 - 200 V
Thermocouples simulator
RTDs simulator

## Optional Items

Pneumatic differential pressure transmitter, Electronic differential pressure transmitter,
Pneumatic pressure transmitter, Electronic pressure transmitter, Residual pressure electronic transmitter, Capacitive probe level transmitter, Pressure switch, Thermostat, Bourdon gauge, Precision thermometers, Pneumatic control valve, Positioners, 4-20mA converters, etc.

## Dimensions

2000x1000x1500 mm Weight: 155 kg

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# TEST STAND FOR CONTROL VALVES

**Level 2 Topic 2**
**Outcome 1 and 2**

The illustration shows the RT 390 with accessory RT 390.01.

- Design and function of control valves
- Determination of Kv and Kvs values
- Data acquisition to plot valve characteristics and step responses

## General

Control valves are key components of process engineering systems. They act as an actuator and create a link between the controller and the system. Control valves are generally used for regulating flows of gases or liquids. Optimum control loop design depends on a sound knowledge of control valve behaviour as well as knowledge of the controlled system response. The mobile test stand permits investigation and testing of different control valve models. A water circuit with a pump and tank is provided for this analysis. Connections permit integration of the valve under test into the water circuit. The flow rate is adjusted by a gate valve and recorded by an electromagnetic flow rate sensor. Two pressure sensors are used to measure the pressure upstream and downstream of the control valve. The supply pressure for electro-pneumatic valves can be adjusted by a pressure regulator on the switch cabinet. The manipulating variable can be set on potentiometers as a current signal. The position feedback from the valve is also returned as a current signal. Motorised valves are actuated by way of pushbuttons. A resistance teletransmitter measures the valve stroke.

Data acquisition software can be used to plot and evaluate valve characteristics and step responses on a PC in a user-friendly way. The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

## Training Program

Together with control valves RT 390.01 and RT 390.06

- Demonstration and functional testing of control valves
- Determination of Kv and Kvs values
- Plotting valve characteristics
- Dynamic response of control valves & plotting step responses
- Influence of supply pressure on pneumatically operated valves
- Maintenance and adjustment

## Technical Specifications

Water circuit with tank, pump and connection for control valves
Electromagnetic flow rate sensor
2 pressure sensors for pressure drop over the control valve
Gate valve to adjust the flow rate
Potentiometer to actuate electropneumatic valves with a current signal
Pushbuttons to actuate motorized valves
Manometer and pressure regulator to adjust the working pressure
Position feedback via current signal (electro pneumatic valves) or teletransmitter (motorized valves)
LABVIEW software for data acquisition via USB under windows XP or Vista

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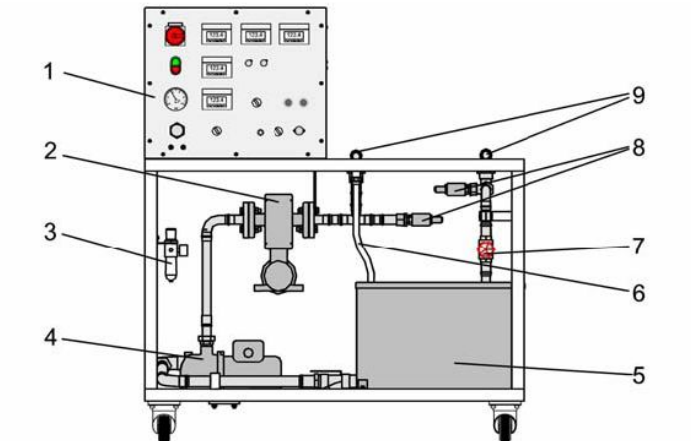
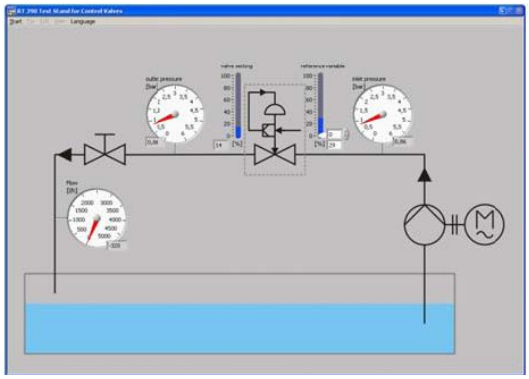



## Legend

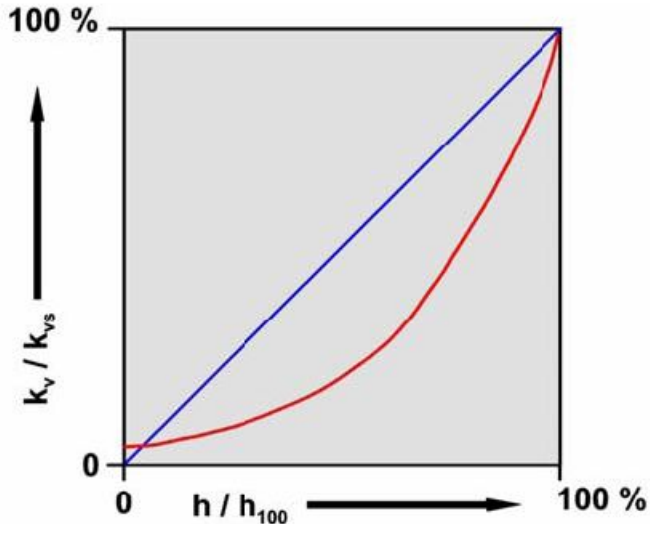
1 Control panel with displays
2 Flow rate sensor
3 Precision input pressure regulator
4 Pump
5 Tank
6 Collecting tray outlet
7 Gate valve
8 Pressure sensor
9 Control valve connecting ports



Screenshot of software

## Technical Data

Tank: approx. 90L
Two-stage centrifugal pump
- max. head: 20m
- max. flow rate: 4m³/h
Signals
- DC: 4...20mA
- resistance: 0...1000 Ohm
Auxiliary power
- AC: 24V
- supply pressure: 0...10bar
Measuring ranges
- flow rate: 0...5000L/h
- pressure (water): 2x 0...6bar
- supply pressure: 0...10bar




Theoretical characteristics of a linear (blue) and equal percentage (red) valve curve. K flow coefficient Kvs flow coefficient h valve stroke

## Dimensions

L1250 x W 750 x H1500
Weight approx 150 kg

## Services

220/240
Air supply

## Delivery

1 trainer
Labview software CD
Instructional material

## Optional Items

RT 390.01 Control Valve, Pneumatic, Kvs 2.5, Equal-Percentage
RT 390.02 Control Valve, Pneumatic, Kvs 1.0, Equal-Percentage
RT 390.03 Control Valve, Pneumatic, Kvs 2.5, Linear
RT 390.04 Control Valve, Pneumatic, Kvs 1.0, Linear
RT 390.05 Control Valve, Electric, Kvs 2.5, Equal-Percentage
RT 390.06 Control Valve, Electric, Kvs 1.0, Equal-Percentage

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# MAINTENANCE OF VALVES, FITTINGS & ACTUATORS


Level 2,
Topic 2
outcome 2,
3 and 4

*** Trainer for maintenance work on industrial valves and fittings**
*** Comparison of 4 different actuators**

## General

Various types of valves and fittings are used in industry. They are suitable for gaseous and liquid media. A distinction is made between valves, plug valves, gates and butterfly valves. Plug valves isolate a pipeline quickly, acting transverse to the flow. A quarter revolution is sufficient for full actuation. Valves adjust the flow rate and require several turns of the spindle for full opening or closing. Gates are not intended to seal off the pipeline completely, but serve to restrict the flow. When one of these valves and fittings is combined with a driving mechanism, the resulting control device is known as an actuator. RT 395 presents three various types of valves and fittings. The trainer investigates the operating response of a segmented ball valve, a butterfly valve, a pneumatic control valve and a pressure reducing valve. The control panel allows the necessary electrical and pneumatic parameters to be set to test and calibrate the valves and fittings. Instruments indicate pneumatic pressures, voltage and current. There is a vice on the workbench for maintenance and assembly work. The workbench also incorporates the necessary tools, and small parts such as seals, for the carrying out of testing procedures.

## Training Program

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

- Function and mode of operation of various valves and fittings
- pneumatic butterfly valve
- pneumatic segmented ball valve
- pneumatic control valve with electro-pneumatic positioner
- Pressure reducing valve
- Pneumatic connection
- Electrical connection
- Familiarisation with linear and equal-percentage valve characteristics
- Planning, execution and assessment of maintenance and repair operations
- Reading and understanding engineering drawings and operating instructions

## Technical Specification

[1] Maintenance work on industrial valves and fittings

[2] Pneumatic control valve with electro-pneumatic positioner DN 25 / PN 16

[3] Butterfly valve with swivel drive DN 100 / PN 16

[4] Pressure reducing valve DN 15 / PN 16

[5] Segmented ball valve with swivel drive DN 40 /PN 16

[6] 2 compressed air ranges, adjustable by fine pressure regulator

[7] Instrumentation: analogue pressure meter, digital ammeter and voltmeter

[8] Electric signal transmitter for positioner in the form of an adjustable current source

[9] The trainer forms part of the GUNT assembly, maintenance and repair training line

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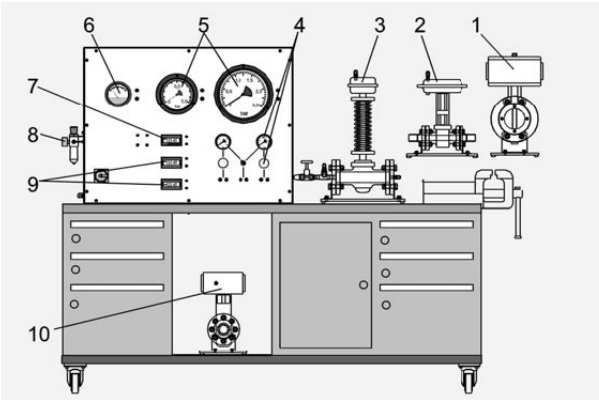



## Legend

1 Butterfly valve
2 Pneumatic control valve
3 Pressure reducer
4 Fine pressure regulator with manometer
5 Manometer
6 Differential pressure meter
7 Display of adjustable current source
8 Air service unit
9 Digital displays for voltage and current
10 Sectioned ball valve

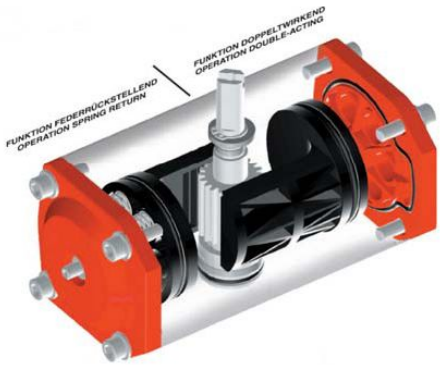
Cutaway of valve with single action pneumatic swivel drive

## Technical Data

Pneumatic swivel drive: single-action with spring return
Measuring ranges
- pressure (bourdon tube manometer):
0...1bar (D=160mm)
0...1.6bar (D=60mm, fine pressure regulator)
0...2.5bar (D=250mm)
0...6bar (D=60mm, fine pressure regulator)
- differential pressure: 0...10kPa
- current (digital display): 0...20mA
- voltage (digital display): 0...20VDC

## Scope of delivery

1 workshop trolley with cabinets and control panel
1 butterfly valve
1 pneumatic control valve
1 pressure reducing valve
1 segmented ball valve
1 set of cables
1 set of compressed air hoses
1 set of tools and small parts (bolts, seals etc.)
1 set of instructional material




Principle of a swivel drive: left: spring-return; right: dual-action

## Dimensions

l x w x h: 2200 x 750 x 1660 mm
Weight: approx. 150 kg

## Services

230V, 50/60Hz, 1 phase
Air supply: 8bar

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# PUMPS, VALVES & FITTINGS TEST STAND

**Level 2 outcome 2 and 4**

*** Plotting characteristics of industrial valves and fittings**
*** Comparison of different valves and fittings * Characteristics of a centrifugal pump**

## General

RT 396 allows the characteristics of different valves and fittings to be compared. The four typical kinds of valves and fittings: plug valve, gate valve, butterfly valve and valves - are represented by a ball valve, a butterfly valve, two gate valves and a control valve. A safety valve and a dirt trap are also investigated. All valves and fittings are flanged, and can be installed in a test system with variable pipe length. The test system is part of a closed water circuit. Pressure measurement points upstream and downstream of the valve and fitting under test are linked by a differential pressure manometer. This manometer is fitted with a pressure switch which activates a warning lamp if the pressure difference becomes excessive, such as when the filter is clogged. An electromagnetic flow rate sensor permits precise recording of the flow rates. The closed water circuit contains three butterfly valves, to isolate the pump, and to adjust the pressure upstream and downstream of the test fitting. Differential pressures across the pump and test fitting, the power consumption and speed of the pump, and the flow rate and opening angle of the control valve are recorded and displayed. The measured data can also be used to plot pump characteristics. A vice is included on a separate workbench for maintenance and assembly work. The workbench also incorporates the necessary tools and connecting hoses

## Training Program

The well-structured instructional material sets out the fundamentals and provides a step-by-step guide through the experiments.

- Characteristics of a centrifugal pump
- Behaviour during operation and function of
- ball valve
- butterfly valve
- gate valve
- wedge gate valve
- control valve
- safety valve
- dirt trap
- Valve characteristics
- Determining the Kvs value of the control valve
- Flow losses at the dirt trap depending on the filter and its load
- Planning, execution and assessment of maintenance and repair operations
- Reading and understanding engineering drawings and operating instructions

## Specification

[1] Trainer for testing various valves and fittings
[2] Installation of the test fitting in a test system of variable length
[3] Safety valve 1", 1.5bar
[4] Gate valve 1" / PN 20
[5] Ball valve with pneumatic drive DN 50
[6] Butterfly valve DN 50 / PN 16
[7] Wedge gate valve DN 50 / PN 16
[8] Electric control valve DN 50 / PN 16
[9] Dirt trap DN 50 / PN 16 with 2 filter elements
[10] Speed-controlled centrifugal pump with frequency converter
[11] Fine pressure regulator adjusts compressed air pressure
[12] Collecting tray under test device
[13] Supply tank with level gauge
[14] Manometers in intake and delivery line of centrifugal pump; pressure measuring points up and downstream of test device for differential pressure manometer with pressure switch
[15] Digital displays for flow rate, power output, speed, position of control valve

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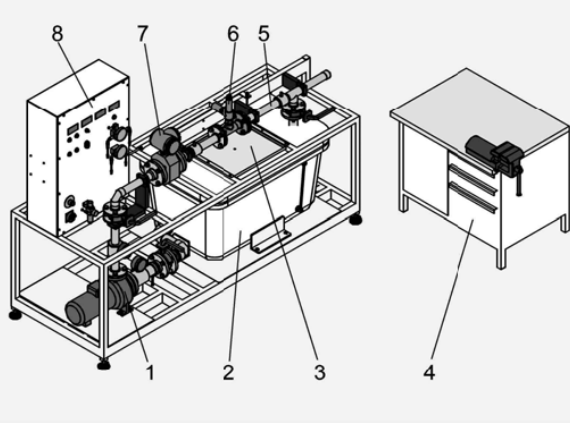
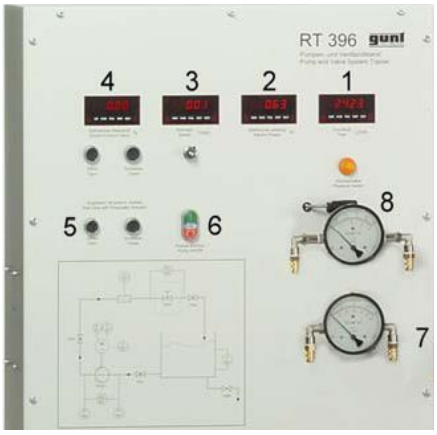


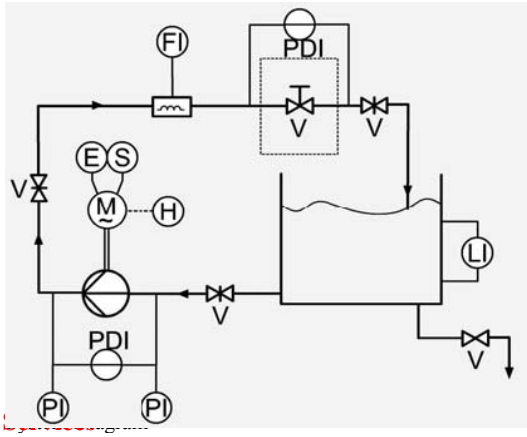

## Legend

1 Pump
2 Supply tank
3 Collector Tray
4 Workbench
5 Test system
6 Test fitting
7 Flowmeter
8 Control panel with displays




## Control panel with system diagram and displays

1 Flow rate
2 Power output
3 Speed with potentiometer
4 Position of control valve (with switches)
5 Switches, opening and closing of ball valves
6 Pump switch
7 Differential pressure manometer
8 Differential pressure manometer with pressure switch for test fitting




400V 3phase
Air supply 8bar

## Dimensions

Test Stand L 2500 x W 950 x H 1900 mm
W=Workbench L 1000 x W 750 x H 870 mm
Weight approx.395kg in total

## Technical Data

Centrifugal pump
- power consumption: 4kW
- max. flow rate: 84m³/h
- max. head: 24m
- speed: 1450...2900rpm

Plastic tank with lid: capacity: 400L
Measuring ranges
- differential pressure manometer: 0...2.5bar / 0...4bar
- manometer: 0...4bar / -1...0.6bar
- flow rate: 0...2000L/min
- opening range of control valve: 0...100%
- power output: 0...4000W
- speed: 0...2900rpm

## Scope of delivery

1 Test stand with centrifugal pump
1 Workbench with tools and hoses
1 Set of test fittings consisting of:
1 control valve. 1 dirt trap. 1 safety valve.
1 gate valve. 1 ball valve. 1 butterfly valve.
1 sluice valve
1 Set of instructional material

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# TEMPERATURE MEASUREMENT
# 2 STUDENT BENCH Trade test compatible


**General**

Temperature measurement in industry is one of the more complex processes since temperature has to be measured over a wide range; from cryogenic to ultra high temperatures which are judged to be higher than the surface of the sun. These temperatures don't only have to be measured but in most cases controlled.

In order to measure accurately and efficiently there is a range of temperature measuring instruments designed to conform to these requirements:

Mechanical type such as diaphragm attached to a movement with a pointer, capillary tube, etc.

Instruments based on the change of e.m.f. developed at the point of contact with another metal.

Instruments based on the change of electrical resistance
Instruments based on the varying amount of radiation from the surface of a body

**Specification**

1 x Type T Thermocouple
1 x Type K Thermocouple
1 x Type J Thermocouple
1 x Type R Thermocouple
1 x PT 100
Wire for each thermocouple
2 x Temperature calibrators
2 x Temperature controllers
1 x Calibrated furnace
1 x Workbench - rubberised

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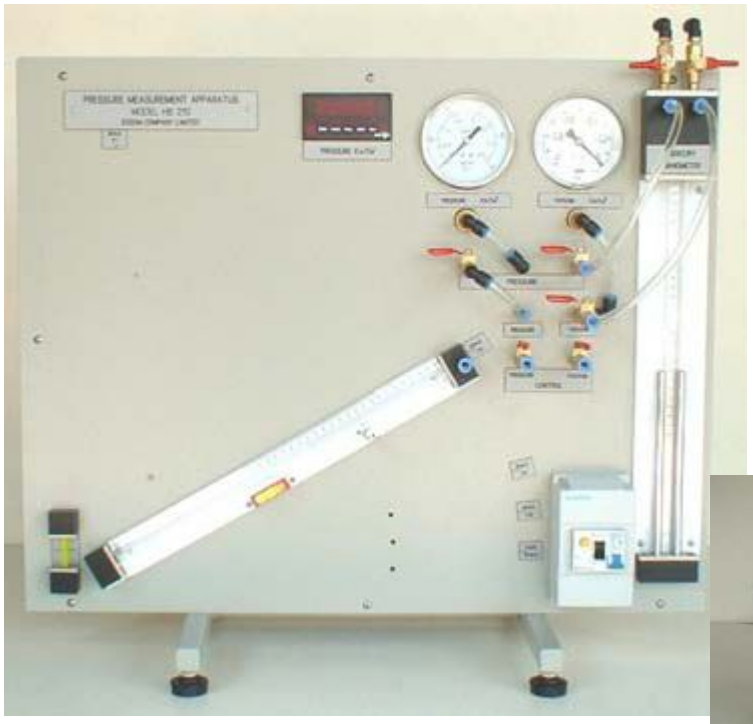
# PRESSURE MEASUREMENT APPARATUS

**Level 2, Topic 3**
**Outcome 1,2 and 3**



Photograph with optional equipment

## General

This is a bench top self contained apparatus to introduce learners to basic pressure measuring devices as well as pressure gauge calibration

The apparatus consists of a mercury and a water manometer, pressure and vacuum gauges, and a diaphragm pump for generating pressure and vacuum.

The pump is installed at the rear of the panel with frontal accessible ports for both pressure and vacuum measurement. A dead weight pressure tester is also supplied

## Services

220/230V AC

## OPTIONAL :

Pressure sensor and indicator.

## Dimensions:

H370 x L700 x H750mm
Weight approx 25kg

## Technical Data

| | |
|---|---|
| Bourbon Tubes | 1 ea 0….1kg/cm$^2$ |
| | 1 ea 0….3kg/cm$^2$ |
| Manometers | 1 ea U tube mercury |
| | 0… 400mm x 1mm grad. |
| | 1 ea Slope inclined |
| | 0….400mm x 1mm grad. |
| | 1:10, 1:5, 1:2, and 1:1 |
| Vacuum pump | 0.18kW |
| Dead Weight Pressure Tester | Stainless steel piston & cylinder |
| | Pressure gauge 0….3kg/cm$^2$ |
| | Cross section 250mm$^2$ |
| | Piston weight 0.5kg |
| | Calibration weights 1x 0.5kg |
| | 2x 1kg |
| | 2x 2kg |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# TEMPERATURE MEASUREMENT APPARATUS

**Level 2**
**Topic 4**
**Outcome 1, 2, and 3**
**Level 3,**
**Topic 2**
**Outcome 1.2, and 4**

## General

This bench top unit is used for studying temperature measurement of several commonly used devices as well as understanding related principles.
Heat sources and means for calibration and accuracy comparison of the different devices is provided.

## Learning program

Physical principles of each device
Calibration techniques
Lead and conduction errors
Dynamic response
Errors
Incorrect applications
Humidity influence

## Services

220/240V AC

## Dimensions

W650 x L750 x H750mm

## Technical Data

**Primary temperature sensing devices**

| | |
|---|---|
| Platinum resistance thermometer | -49.9ºC…199.9ºC x 0.1ºC res. |
| Thermistor | 0…..100 ºC x 0.1ºC resolution |
| Thermocouple Type K – NiCr/NiAl | -75...120 ºC x 0.1ºC resolution |

**General industrial temperature measuring devices**

| | |
|---|---|
| Bimetallic thermometer | 0…..200 ºC |
| Vapour pressure thermometer | 20….150 ºC |
| Mercury glass thermometer | 0……150 ºC |
| Surface temperature indicator strips | ……..250 ºC |

Wet and Dry bulb thermometer

**Heat Sources**

Hot plate with thermostat and stainless steel pot
Hot air blower with thermometer stand
Ice pail

**Miscellaneous**

Millivoltmeter
Digital readout for resistance thermometer
Digital readout for thermistor
Digital readout for thermocouple

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# FLOW MEASUREMENT TEST SET

**Level 2, Topic 5, Outcome 1, 2 and 3**
**Level 3, Topic 3, Outcome 2, 3, 4, 5 (with optionals)**

## General

This is a bench top self contained water circulating unit for studying the various flow measuring instruments including primary flow measuring devices.
The flow measuring instruments are connected in series and all except the measuring tank are arranged on a waterproof panel.
Measurement of flow by a primary flow measuring devices is by coefficient of discharge which is determined from a pressure drop across the device and its flow rate. The flow rate is obtained from a water meter reading and a stop watch. The pressure drop is measured by differential pressure using manometers. Pressure tapping is by small ball valves with quick connection. The water tanks are behind the panel.
The flow rate is varied by a flow control valve.
The water tank and the pump are situated behind the panel.

## Training Program

**Comparison of differential pressure at various flow rates for:**
Venturi
Orifice
Pitot tube
Variable area flow meter

**Determination of coefficient of discharge for:**
Venturi
Orifice
Pitot tube

**Comparing flow rates from :**
Water meter
Variable area flow meter
Measuring tank

## Technical Data

| | |
|---|---|
| Pump | 0.37kW |
| Maximum Flow Rate | Over 8L/min |
| Maximum pressure | Over 18m water |
| Storage tank | approx 60L |
| Primary flow measuring devices in clear plastic" | |
| Venturi meter | 29mm dia.17mm throat with 21° taper and 14° outlet taper |
| Orifice meter | 20mm dia on 29mm tube |
| Pitot tube | on 19mm tube |
| Other flow measuring devices | |
| Water meter & stop watch | |
| Rotameter | up to 75 L/min |
| Measuring tank | 40 L |
| Differential Pressure Measurement | |
| Water manometer | 8 tubes – 950mm x 1mm graduation |
| **Power Supply** | 220/240 AC |

## Optional Items

HF 013 ISA nozzle on 29 mm diameter tube.
HF 031 Differential pressure sensor and indicator. 0-250 cm water.
HF 235-050 Computer Interface
This includes sensors, analog to digital signal converter with software for data display and analysis by computer .
HF 010 Flow sensor and indicator. .

**Other flow measuring devices can be supplied on request.**

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# ANALYTICAL PROCESS CONTROL

**Level 4 Topic 3 outcome 1, 2 and 5**

## General

The analytical process control system demonstrates the control of the quality of industrial and waste water. It combines chemical procedures with applied principles of control engineering. The mobile laboratory unit is dimensioned in away to allow experiments without neglecting the characteristics if industrial plants. Neutral water is mixed with diluted sodium hydroxide and the resulting ion load is measured. The addition of diluted sulphuric acid neutralizes the solution. Controlled aeration changes the oxygen content. Another experiment controls the redox potential of water using diluted iodine solution. All processes are equipped with extensive instrumentation and are controlled by industrial controllers. Transparent reaction tanks enable the processes to be observed

## Training Program

Simulation of a salt load by addition of sodium hydroxide via a conductivity control system

pH value control of the solution using sulphuric acid

Change in the oxygen content by means of controlled aeration with compressed air

Control of the redox potential via the addition of diluted iodine solution

- **Monitoring and control of industrial waste water**
- **High quality instrumentation in accordance with industrial standards**
- **Four completely independent control loops**
- **Use of industrial monitoring pumps**

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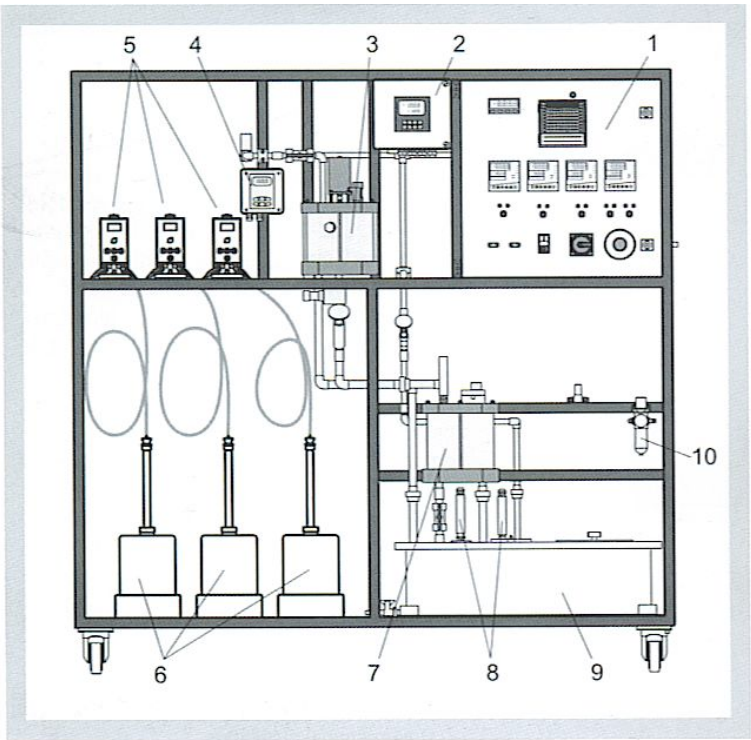


## Legend

1 Control panel with industrial controllers and recorders
2 Oxygen content measuring instrument
3 Reaction tank
4 Conductivity measuring instrument
5 Metering pumps
6 Chemical tanks
7 Reaction tank
8 Measuring probes
9 Collecting tank
10 Compressed air connection

## Technical Data

Chemicals: Sodium Hydroxide NaOH 2%
Sulphuric acid $H_2SO_4$ 2%
Iodine solution ratio $H_2O$:I 100:1

Metering pumps: Max. 1.7 Ltr/h
pH single rod measuring sensor 1…12pH

Conductivity sensor with integrated PT-100
temperature sensor: 0.01…20mS/m

Oxygen sensor: 0…60mg/ltr $0_2$

Redox measuring electrode: 0…1000mV

Universalcontroller, microprocessor based
Multi channel recorder: 6 channels

## Specification

1 Analytical process control system to monitor and modify industrial waste water
2 High quality instruments and control equipment for conductivity measurement, pH-value control, oxygen enriching, redox potential control.
3 pH-value single rod measuring sensor 0…12pH
4 Oxygen sensor 0…60mg/ltr $O_2$
5 Industrial redox measuring electrode 0…1000mV
6 Microprocessor controlled universal controller
7 6-channel recorder
8 Transparent reaction tanks
9 Sturdy steel frame with castors

## Scope of delivery

1 Analytical process control system
1 Instruction manual

## Dimensions

L1800 x W700 x H 1850 mm
Approx. 150kg

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# PROCESS CONTROL & INSTRUMENTATION RIG


## General

The Process Control and Instrumentation rig provides a self-contained process control system which is representative of many industrial systems that are used in the chemical, oil. Food, water and other process industries.

The rig is fitted with state-of-the-art intelligent process **instruments** and actuators which are networked via **PROFIBUS** PA and DP to communicate with a Programmable Logic Controller **(PLC)**.

The controlling PLC can be configured to implement a number of different control strategies for flow and level control using cascade, feed-forward and multi-variable strategies.

The rig also provides separate level **alarms** and process and device temperature monitoring. Further, the control system is linked via an Ethernet Local Area Network **(LAN)** to a modern PC platform and gateway which provides modem Control and Data Acquisition **(SCADA)** monitoring and control of the process.
Asset management tools are also available on the PC workstation for **calibration, diagnostics, predictive maintenance** and other engineering instrumentation and actuation tasks.

Full specification will be provided on request

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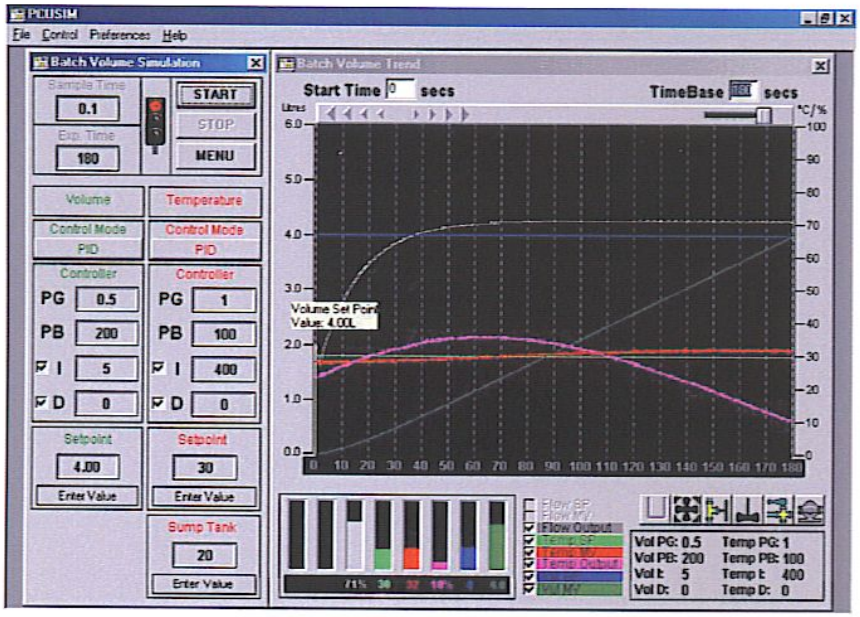
# Process Control Simulator Software
# Model: PCUSIM




**FEATURES.**

- PID, Manual & Open Loop Control (Open Loop available for flow only).
- Perform experiments under same initial conditions with different control parameters.
- 4 control scenarios: flow rate, temperature, batch and fluid level.
- Analyse, rewind, save & print graphs.

PCUSIM is a simulation environment for process control. The program is aimed at Further and Higher education students learning process control and PID (Three Term) controllers

The PCUSIM represents a process unit with two tanks – a process tank and a sump tank – as well as connecting pipes, a heater, and an alternative flow path through a cooler. Flow rate through the pipes, fluid temperature in the process tank and pipes, and fluid level in the process tank are all measured. This configuration can be used to model control of flow rate in pipes, temperature in a tank, fluid level in a tank, or batch control of a specified volume at a specified temperature as per batch processes in the chemical industry.

PCUSIM has a graphical display for experiments in all of these areas, complete with set-points, real-time plotting. PID and manual control options are available, with all control parameters clearly displayed. Students can experiment with the different control situations and different control parameters to gain a feel for PID and learn at their own pace.

Graphical display of all information is provided in real time. Graphs can be analysed, rewound, saved and printed. Experiments can be performed and teaching benefits drawn. Students can, in addition, perform the same experiment many times with the same initial conditions and different control parameters, allowing closer comparison of outcomes.

For each of the flow rate, temperature, fluid level and batch volume controls scenarios, clear displays show Start and Stop buttons, the Control mode, the principal variables being measured, any PID parameters, set-points and parameters, real time graph with start time and time base, state of current reading or reading being examined, tick boxed for which traces to display, relevant controls with displays like state of choke valve, cooler, flow divert, stirrer, drain valve and heater. Open loop control of flow rate is also available.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# SINGLE PROCESS TRAINERS

**FLOW RATE CONTROL Fcb**

This unit is designed for automatic flow rate control using a calibrated diaphragm, a pneumatic valve, a differential pressure transducer and a PID controller

Can be supplied with freely connectable inputs and outputs

PID – Open Loop – Closed loop Tuning methods etc
Available with supervisory software

**LEVEL CONTROL Lcb**

This unit is designed for automatic level control in a small tank using an electronic level transmitter, a pneumatic valve and a PID Controller
Can be supplied with freely connectable inputs and output

PID – Open Loop – Closed loop Tuning methods etc

Available with supervisory software


**PRESSURE CONTROL Pcb**

This unit is designed for automatic pressure control in a tank or in a pipe using an electronic pressure transmitter, a pneumatic valve and a PID controller.

Can be supplied with freely connectable inputs and output
PID – Open Loop – Closed loop Tuning methods etc

Available with supervisory software

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## TEMPERATURE CONTROL Tcb

This unit is designed for automatic temperature control of a liquid using a heat exchanger, a hot water source, a pneumatic valve and a PID controller.
Can be supplied with freely connectable inputs and output
PID – Open Loop – Closed loop
Tuning methods etc

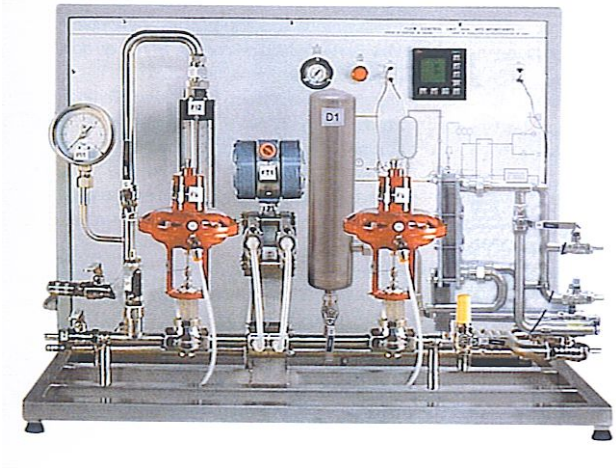
Available with supervisory software

## pH CONTROL pHcb

This unit is designed for the automatic control of pH in a small reactor, using PID Controller adjusting the flow rate of the acid solution

Can be supplied with freely connectable inputs and output
PID – Open Loop – Closed loop
Tuning methods etc

Available with supervisory software



## MULTI PROCESS STAND Mpb

This unit is designed for the automatic control of flow rate, level, temperature and pressure by using the same control unit but modifying the hydraulic circuit

Includes supervisory software

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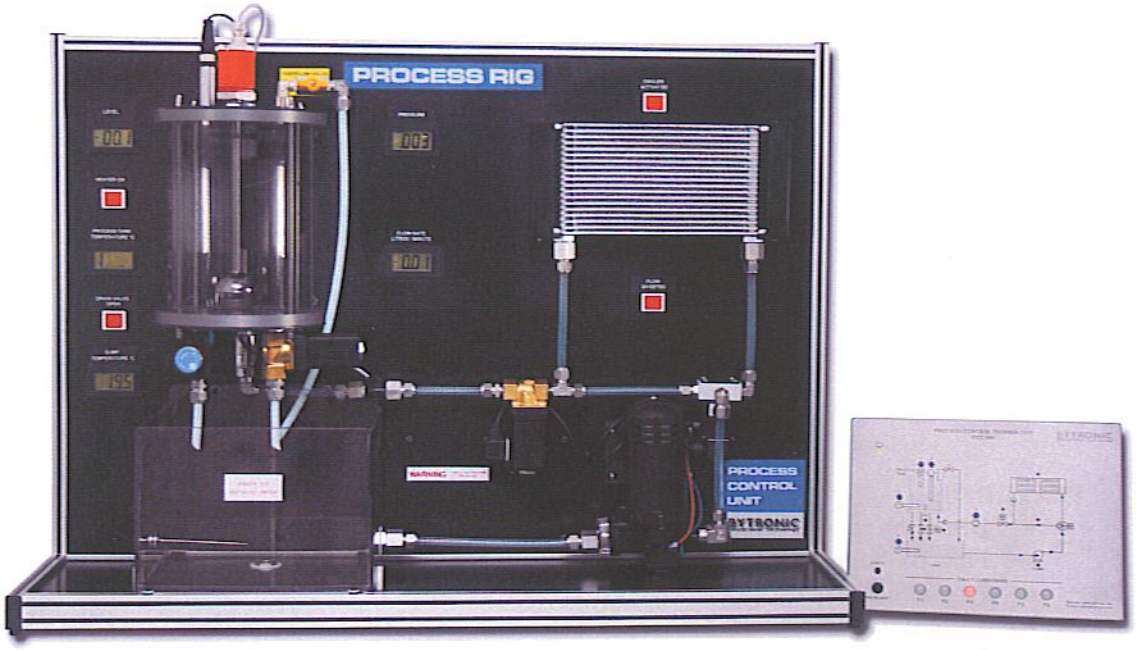
# PROCESS CONTROL TECHNOLOGY PCT100




**FEATURES**
Control of Discrete Processes
PID Control
Temperature, Level, Pressure and Flow Control
Graphical monitoring of real time processes

The PCT-100 Process Control Technology unit is a bench top unit that represents a system typically found in the process industry. Consisting of the Process Module and a Control Console with a Power Supply, together with a comprehensive interactive control program. The software has been developed to act as an inclusive PID teaching tool and provides historical data trending features. The Control Console has a representation of the Process Module on the front and includes fault switches.

Liquid contained in a Sump Tank is pumped around the process unit into a Process Tank the Flow rate, Level, Temperature and Pressure can be controlled. Sensors are used to determine the Pressure and Level in the process tank and a sensor in the flow pipe for the Flow rate with FT 1000 temperature sensors to determine the temperature of the liquid in the Sump and Process Tank and a magnetostrictive sensor is used to measure the Level. Forced air cooling is used to cool the liquid in the system. In addition to supplying this data to the controller, it is also represented on LCD units on the Process Module. Two proportional valves are used to control flow into and out of the process tank, a manually adjustable needle valve is used to add disturbances to the system and a pressure relief valve fitted for safety.

The Control Console contains connections to allow either PC (USB) and PLC control or a PID controller.

Exercises for the PCT-100 begin with setting up and executing a process cycle, through to optimising the PID controllers by estimating P, PI and PID parameters using Ziegler Nichols process reaction curve or ultimate cycle methods. Formulation of problems and resulting solutions coupled with bench-marking are manifest through tutorials.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# PC CONTROLLED SINGLE PROCESS

## Process Control Technology - Flow Module
## Model: PCT-M1

**FEATURES:**

- Bench top unit
- Flow control process with transparent rotameter
- Proportional valve
- Turbine flow transducer
- Pump variation to generate disturbance.
- Connection to a PC via USB interface
- Graphical software with control and data logging
- Courseware Manual

## Process Control Technology Level Module
## Model: PCT-M2

**FEATURES:**

- Bench top unit
- Level control process with transparent tank
- Proportional valve
- Speed controlled pump
- Level measurement via pressure transducer
- Pump variation to generate disturbance
- Connection to a PC (PC not included) via USB interface
- Graphical software with control and data logging
- Courseware manual

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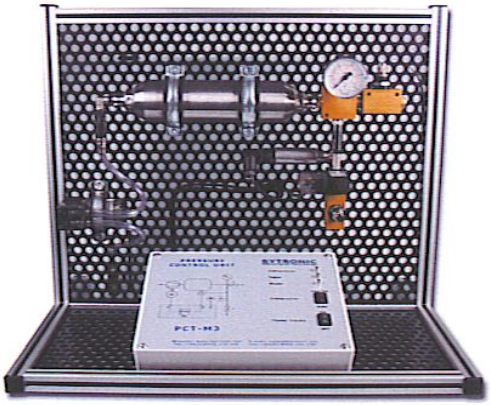
## Process Control Technology Pressure Module
## Model: PCT-M3



**FEATURES:**

- Bench top unit
- Pressure control
- Speed controlled compressor
- Pressure range 0...1bar
- Electronic pressure transducer
- Manual valve to generate disturbances
- Connection to a PC (PC not included) via USB interface
- Graphical software with control and data logging
- Courseware manual

## Process Control Technology Temperature Module
## Model: PCT-M4

**FEATURES:**

- Bench top unit
- Temperature control
- Heating using Peltier element
- Temperature range 0...100°C
- Temperature sensors at 3 different positions
- Fan can be switched to create a disturbance
- Connection to a PC (PC not included) via USB interface
- Graphical software with control and data logging
- Courseware manual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# DE LUXE TRAINING BENCH

***Feature***
.The benches are designed for the use of training,developing sevices,calibration and assembling benches

***TB 1000***

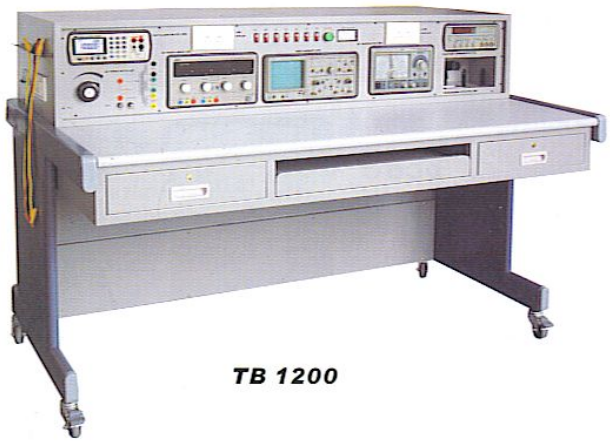
***TB 1000***
***Training bench***

.Height:85cm
.Width: 150cm
.Depth: 90cm
.4 adjustable stands and 4 wheels

***TB1100***
***Training bench + Top frame***

.Traning bench (TB1000)
.Top frame

***TB 1100***



***TB 1200***

***TB1200***
***Training bench + instrument housing***

**Fully fitted to clients specification**

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LEVEL 4

# TOOLS FOR AND EQUIPMENT FOR STUDENT PRACTICAL WORK

(Maintenance – disassemble – assemble – install )

Bourdon tube

Bellow

Thermocouples

RTD

Differential pressure flow

Variable area flow

Positive displacement flow

Turbine flow meter

Thermal mass flow

Electromechanical

Pneumatic transmitters & converters

Pressure electronic transmitters

Expansion temp. measurement

Thermistors

Electromagnet flow

Ultrasonic flow

Vortex

Coriolis

Conductive level

Capacitive level

Vibrating level

Electromechanical level

Hydrostatic level

Ultrasonic level

Microwave level

Nucleonic level

Load cells

Conductivity analysers

Turbidity analysers

Humidity (dew point)

pH



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# CD ROMS
# INSTRUMENTATION & PROCESS CONTROL

**Please note that these programs are predominantly imperial as they were produced for the US market by the Instrument Society of America, now the Instrument Society in Automation which is the most prestigious player in this field**

More than 6,000 corporate customers have chosen ITC's iKNOW online and Activ™ CD-ROM training over the past 20 years.

Our courses have been developed by subject matter experts with substantial experience in actual industrial environments, so they understand how the real world - your world - works. They've put together a curriculum that is:

**Results-driven – Specifically engineered with the capabilities and limitations of the plant environment in mind, so you get the most out of every minute.**

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**Comprehensive – There's pre-testing, final exams and practice sessions**

**Comprehensive – There's pre-testing, final exams and practice sessions** **that use a variety of formats to reliably assess your employees' grasp of subject matter.**

**Trackable – Our systems make it easy to monitor and manage the progress of all your employees.**

**Easy to access – No proprietary plug-ins are required. ITC offers courses**

**online as well as through other delivery methods, so you can train anyone, anywhere, any time.**


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# Gate Valve Repair (A9101)

**Prerequisites:** This lesson is designed for participants familiar with the operation of gate valves and the proper use of hand tools and precision measuring instruments.
**Description:** This lesson addresses the procedures for disassembly, inspection, and reassembly of a typical gate valve. The lesson covers the locations and functions of valve components. Procedures for disassembling, inspecting, and measuring valve parts and procedures for lapping the disc and checking seat contact are also covered.
**Objectives:** Identify the parts of a gate valve and describe their functions ● Inspect a valve and make adjustments to stop leakage ● Position rising stem and non-rising stem valves to the half-open position ● Remove and disassemble the bonnet assembly of a gate valve ● Use a telescoping gauge to determine if a stuffing box is round ● Perform a runout to determine if a stem is bent ● Use an outside micrometer to determine if the stem has excessive wear ● Lap a disc and perform a contact check of disc mating surfaces ● Reassemble the bonnet assembly of a gate valve ● Perform a contact check to determine if there is a proper seal between the seat and disc of a gate valve.

# Globe and Control Valve Repair (A9102)

**Prerequisites:** This lesson is designed for participants familiar with the basic operation of globe and control valves and the proper use of hand tools and precision measuring instruments.
**Description:** This lesson provides guidelines for repairing globe and control valves including procedures for disassembling, inspecting, and reassembling both globe and control valves.
**Objectives:** Identify the basic components of a typical globe valve ● Disassemble and inspect a globe valve for damage ● Describe what lapping is and explain when it is used ● Complete a dye check ● Reassemble a globe valve ● Identify the basic components of a typical control valve ● Disassemble and inspect a control valve for damage ● Reassemble a control valve.

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# Instrumentation Series

## Analyzers Library (5 CD's)

*20-30 hours of training*

**This comprehensive INVOLVE® multimedia-training program was produced in association with the Instrument Society of America USA.**

This five individual lesson CD's program trains participants in Me principles of process analysis and Me operation and applications associated with spectroscopic, electrochemical, and chromatographic analyzers.

**Audience**: This program is excellent for training instrument technicians as well as for the multi-craft training needs of process and manufacturing.

## Principles of Process Analysis (AAS01)

**Prerequisites:** This lesson is designed for participants with an understanding of industrial process control. Participants should also have a basic understanding of chemistry and physics.

**Description:** This lesson introduces participants to the principles of process analysis. The advantages of process analysis for industry are discussed and the scientific principles of the various process analysis methods, such as spectrometry, chromatography, electrochemical and physical property analysis are described.

**Objectives:** Describe the concept of process analysis ● Distinguish between process and laboratory analysis ● Describe how process analysis aids in conforming to environmental and regulatory policy as well as safety and loss prevention standards ● Understand safe and effective process analyzer use ● Describe the principles of thermal conductivity analysis, combustible gas detection, electrical conductance analysis, electrochemical analysis, zirconium ● Oxide oxygen detection, ph analysis, opacity analysis, and spectrometric analysis ● Explain the beer-lambert law ● Identify the means of measuring density in fluids ● Identify the methods to measure moisture in fluids ● Describe how moisture is measured in gases and liquids using the electrolytic method, the piezoelectric method, and the aluminum gas method ● Describe the principles of gas chromatography and mass spectrometry ● Explain the methods.

## Spectroscopic Analyzers (AAS02)

**Prerequisites:** This lesson is designed for participants familiar with industrial process control and process analysis. Participants should also have a basic understanding of chemistry and physics.

**Description:** This lesson introduces participants to spectroscopic analyzers and describes their principles of operation, components, and measurements. Various analyzer configurations are explained and the operation of mass spectrometers is described.

**Objectives:** Define the term electromagnetic spectrum ● Identify UV, visible, and infrared regions on electromagnetic spectrum diagrams ● Describe common types of molecular excitation ● Identify and describe typical spectroscopic analyzer components and explain their functions ● Explain the function of optical filters in limiting radiation to the wavelength of interest ● Explain the necessity of various analyzer configurations ● Describe the operation of split beam, single beam, and dual beam analyzers ● Describe the configuration
and operation of a nondispersive analyzer ● Describe the configuration of multicomponent analyzers ● Explain the operation of a mass spectrometer ● Describe the functions of a mass spectrometer's control unit ● Discuss spectroscopic analyzer sampling considerations.

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# Gas Chromatographs (AAS03)

**Prerequisites:** This lesson is designed for participants with an understanding of industrial process control, process analysis, and spectroscopic analysis. Participants should also have a basic understanding of chemistry and physics.
**Description:** This lesson introduces participants to gas chromatography and describes gas chromatograph principles of operation, components, and Applications appropriate for gas chromatographs are identified and discussed.
**Objectives:** Identify gas chromatograph system components ● Identify the two most common types of columns: liquid on solid and active solid columns ● Identify the components of a column switching system ● Explain column efficiency- define resolution and peak interface ● Explain the effects of oven temperature, sample size, and carrier gas flow on chromatograms ● Explain the function of a programmer ● Define each component of a standard chromatogram ● Explain methods of determining column switching times for back-flushing ● Describe how to program and calibrate a gas chromatograph ● Be able to identify appropriate applications for using a gas chromatograph, such as butadine analysis and trace component analysis.

# Air and Water Analysis (AAS04)

**Prerequisites:** This lesson is designed for participants with a basic understanding of industrial process emissions and effluents and the regulations governing them. Participants should also have a basic knowledge of the principles of process analysis, spectroscopic analysis, and gas chromatographs.
**Description:** This lesson trains participants to apply the concepts and terminology associated with the principles of process analysis to air and water analysis. The agencies and regulations governing air and water quality are described, and the ways in which various types of analyzers detect and measure the components in air and water are discussed.
**Objectives:** Explain the role and importance of analyzers and detectors for air and water monitoring ● Identify EPA and OSHA regulatory issues surrounding air and water monitoring ● Identify and describe the fundamental operating principles of paramagnetic, zirconium oxide, and low temperature instruments ● Identify air quality applications for spectroscopic instruments ● Identify the operating principles of opacity monitors and infrared and ultraviolet stack analyzers ● Identify air quality applications for gas chromatography ● Identify water quality applications for electrochemical instruments ● Identify the operating principles of pH analyzers, ion-specific electrode analyzers, conductivity analyzers, and dissolved oxygen analyzers ● Identify water quality applications for spectroscopic instruments ● Identify water quality applications for flame ionization detection ● Identify the principles of operation for flame ionization detectors.

# Process Sampling Systems (AAS05)

**Prerequisites:** This lesson is designed for participants with an understanding of industrial process control, process analysis, spectroscopic analysis, gas chromatographs, and air and waver analysis. Participants should also have a basic understanding of chemistry and physics.
**Description:** This lesson introduces participants to the tenets of sound simple handling system design for process analyzers and covers each of the major sections usually included process interface, sample transport, sample conditioning, and sample disposal. Multistream switching and contamination prevention strategies are also covered.
**Objectives:** Identify the reasons for using a sample handling system in process analysis ● Identify the importance and characteristics of a well-designed sample handling system ● Identify the reasons for using a sample handling system in process analysis ● Describe the operating principles of sample handling systems ● Recognize sample system components ● Identify the materials of construction in different sample handling systems that enable components to withstand any corrosive effects of the sample ● Identify the methods to ensure a safely maintained sample handling system ● Identify the importance and function of the sample handling transport system ● Identify the factors that determine lag time in a sample transport system ● Explain the importance of sample conditioning ● Describe and explain the different ways that samples can be conditioned ● Explain the importance of proper filter maintenance ● Explain how block-and-bleed and double, block sample switching systems operate.

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# Control Valves Library (4 CD's)

*16-24 hours of training*

**This comprehensive INVOLVE® multimedia-training program was produced in association with the Instrument Society of America USA)**.

This four individual lesson program trains participants in the function, operation, maintenance, and troubleshooting of common types of control valves.

**Audience**: This program is excellent for training instrument technicians as well as for the multi-craft training needs of process and manufacturing.

## Body Types and Trim (ACV01)

**Prerequisites:** This lesson is designed for participants familiar with industrial process control, specifically single loop control and multiple loop control. A working knowledge of fluid flow characteristics, fluid flow measurement, and typical elements in process loops is recommended.

**Description:** This lesson explains control valve selection factors and demonstrates typical linear and rotary control valve functions and applications. Control valve bodies for several types of valves including globe, butterfly, and ball valves are described. The function and components of valve trim, including the relationship between flow characteristic and trim type is explained.

**Objectives:** Define control valve function in process systems ● Explain how control valves are used in process industries ● Describe how control valves can affect process efficiency, product quality, maintenance, safety, and the environment ● Describe the systems analysis approach to selecting a control valve ● List the types of data needed to choose a control ● Valve for a system ● Identify examples and applications of linear and rotary valves as well as the associated function and components of valve trim ● Describe how differential pressure and flow path affect fluid flow ● Describe how the ability of trim to withstand corrosion and erosion affects trim design ● List trim materials that can withstand corrosion and erosion ● Describe advantages and disadvantages of various packing materials ● Describe seal designs that are required where leakage is not acceptable.

# Actuators and Positioners (ACV02)

**Prerequisites:** This lesson is designed for participants familiar with industrial process control, specifically single loop control and multiple loop control, as well as control valve body types and trim. A working knowledge of fluid flow characteristics, fluid flow measurement, and typical elements in process loops is recommended.

**Description:** This lesson trains participants to recognize, identify, and understand actuators and positioners as they relate to control valve trim. The parts and operation of diaphragm and piston actuators as well as pneumatic and electropneurnatic positioners are demonstrated.

**Objectives:** Describe the principles of pneumatic valve actuation ● Identify diaphragm actuator parts ● Describe actuator response ● Describe the operation of piston actuators ● Identify the advantages and limitations of pneumatic actuators ● Describe electric actuator operation ● Identify common actuator and positioner types ● Identify positioner function ● Describe principles of pneumatic positioner operation ● Identify positioner parts ● Describe how positioners can improve valve response time ● Describe how positioners can change valve flow characteristics ● Describe how positioners can change actuator response ● Describe the selection factors that indicate the appropriate actuator or positioner for system applications ● Match failsafe requirement with the appropriate actuator response ● Identify external fail-safe devices used with piston actuators.

# Body and Trim Maintenance (ACV03)

**Prerequisites:** This lesson is designed for participants familiar with industrial process control, specifically single loop control and multiple loop control, as well as control valve body types and trim, and positioners and actuators. A working knowledge of fluid flow characteristics, fluid flow measurement, and typical elements in process loops is recommended.

**Description:** This lesson applies the concepts and terminology associated with control valve body types and trim, actuators and position to the disassembly, repair, parts replacement and reassembly of linear and rotary action control valves. Symptoms of valve malfunctions, lapping, and post-repair tests are also covered.

**Objectives:** Describe control valve malfunctions ● List causes and effects of control valve malfunctions ● Recognize the importance of following facility safety guidelines and manufacturer's recommendations for valve maintenance ● Describe linear valve disassembly steps ● Clean and inspect linear valve packing and trim ● Recommend replacement



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of linear valve trim parts ● Describe linear valve parts replacement ● Describe linear valve packing replacement ● List linear valve re-assembly steps ● Determine the outcome of linear valve stroking ● Describe linear valve leak testing ● Explain the necessity of linear valve lapping ● Describe the lapping process ● Describe rotary valve disassembly steps ● Clean and inspect rotary valve packing and trim ● Recommend replacement of rotary valve trim parts ● Describe replacement of other rotary valve parts ● Describe replacement of rotary valve packing replacement ● Describe rotary valve re-assembly ● Determine outcome of rotary valve stroking.

# Actuator and Positioner Maintenance (ACV04)

**Prerequisites:** This lesson is designed for participants familiar with industrial process control, specifically single loop control and multiple loop control, as well as control valve body types and trim, and the operating characteristics of positioners and actuators. A working knowledge of fluid flow characteristics and the other elements in process loops is recommended.

**Description:** This lesson introduces participants to causes and symptoms of actuator and positioner malfunctions and applies the concepts and terminology of actuators and positioners to the disassembly, repair, parts replacement and re-assembly of diaphragm and piston actuators.

**Objectives:** List common symptoms of a failed diaphragm actuator ● List the causes of a diaphragm actuator failure ● List maintenance requirements for a diaphragm actuator ● Remove and inspect the stem and diaphragm assembly and the range spring and seal bushing on a diaphragm actuator ● Replace the gasket and O-ring on a diaphragm actuator ● List common symptoms of a failed piston actuator ● List the causes of piston actuator failure ● List maintenance requirements for a piston actuator ● Remove and inspect the ring and the stem and piston assembly on a piston actuator ● List common failures of pneumatic and electro-pneumatic positioners and the causes of failure ● List maintenance requirements for a pneumatic positioner ● Inspect and clean the pilot relay assembly on a pneumatic positioner ● List the causes of i/p transducer failure on an electro-pneumatic positioner ● Adjust the zero and span on an electro-pneumatic positioner.

# Controller Tuning Library (1 CD)

*4-6 hours of training*

This comprehensive INVOLVE® interactive multimedia training program was produced in association with the Instrument Society of America (ISA). This one lesson program trains participants in three methods of controller tuning and the various steps needed to be taken in each method.

**Audience**: This program is excellent for training technicians, operators, control practitioners and engineers as well as for the multi-craft training needs of process and manufacturing facilities.

# Controller Tuning (ACTAV)

**Prerequisites:** This lesson is designed for participants familiar with the basics of instrument control including the proportional, integral, and derivative control modes.

**Description:** This lesson explains tuning methods and principles behind the three methods of tuning a controller: ultimate, reaction curve, and trial and error. The lesson presents the characteristics of a properly timed process response and relates these to proportional, integral, and derivative control actions. In addition, step-by-step procedures for tuning controllers using each method are demonstrated.

**Objectives:** Define controller tuning and its purpose as used in a process control system ● Define a process response ● Explain the significance of a 1/4 decay reaction curve ● Perform the preliminary steps for tuning a controller ● Stabilize a process on manual control before using the ultimate method ● Obtain the value of and calculate the proper setting for a proportional band or gain ● Find the value of the ultimate period ● Calculate the proper settings for PI, PD, and PID controllers ● Verify adjustments ● Obtain and interpret a
process reaction curve ● Calculate the process gain, dead time, time constant, and controller settings using the reaction curve method ● Interpret a process response to determine the proper setting ● Using the trial and error method, tune the proportional mode.



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# Digital Instrumentation Library (2 CD's)

*8-12 hours of training*

**This comprehensive INVOLVE® interactive multimedia training program was produced in association with the Instrument Society of America (ISA)** This program consists of two individual lesson CD's that train participants in the principles of digital instrumentation and signal transmission.

**Audience**: This program is excellent for control practitioners, engineers, and technicians as well as for the multi-craft training needs of process and manufacturing facilities.

## Smart Transmitters (ADI01)

**Prerequisites:** This lesson is designed for participants familiar with digital signal transmission, process control principles, and the function of transmitters in process loops.

**Description:** This lesson introduces digital electronics and teaches the principles of operation, the functions of the electronic components, and the signal characteristics. The lesson also demonstrates operation of the hand-held interface for system configuration.

**Objectives:** Describe the principles of analog and digital signal theory ● Describe the benefits of digital signal transmission ● Describe and identify the signal processing capabilities of smart transmitters ● Describe the major features and characteristics of smart transmitters ● Describe the characterization function, special installation requirements, and signal conditioning of a smart transmitter ● Describe the function of a hand-held interface device ● Describe configuration parameters and demonstrate configuration of a smart transmitter ● Describe the test functions of smart transmitters ● Demonstrate the procedure for doing a loop test with a hand-held interface ● Describe the use of a smart transmitter in a temperature, flow, or pressure measurement loop.

## Single Loop Digital Controllers (ADI02)

**Prerequisites:** This lesson is designed for participants familiar with digital signal transmission, control principles, and the function of transmitters in process loops.

**Description:** This lesson introduces the principles of operation, characteristics, and capabilities of single loop digital controllers, including controller components and signal processing capabilities. In addition, the lesson demonstrates the configuration and tuning of single loop digital controllers.

**Objectives:** Describe digital controller principles and capabilities ● Recognize alarm conditions and solve self-diagnostic errors ● Identify and use the features on a display panel ● Identify and state the function of various controller boards ● Demonstrate how the controller processes analog and digital input signals ● State the purpose of function blocks ● Demonstrate the procedure for diagramming a controller configuration ● Read PID, feed forward, and cascade controller diagrams ● Identify different programming devices ● Label configuration keypad buttons and use them to enter configuration data ● State the purpose of the lockout function and locate the lockout switches ● Label and use the portable
configurator to enter data ● State the purpose of tuning and list the different tuning methods ● Explain self-tuning principles ● Explain when an adaptive control is needed ● Explain automatic tuning principles.

# *Distributed Control Library (2 CD's)*

*8-12 hours of training*

**This comprehensive INVOLVE® interactive multimedia training program was produced in association with the Instrument Society of America (ISA).** This program, consisting of two individual lesson CD's, trains participants in distributed contra techniques, architecture and hardware as well as in the methods used to maintain and troubleshoot distributed control systems.

**Audience**: This program is excellent for training technicians, operators, control practitioners and engineers as well as for the multi-craft training needs of process and manufacturing facilities.

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# Distributed Control Fundamentals (ADC01)

**Prerequisites:** This lesson is designed for participants familiar with process operations, digital electronic theory, and test instruments and devices.

**Description:** This lesson provides an understanding of the fundamentals of Distributed Control Systems (DCS). The evolution of computer control systems is discussed and the architecture of contemporary DCS is described in detail. The lesson covers hardware, configuration, data communications, user interface and 1/0 devices.

**Objectives**: Describe direct digital control ● Describe a supervisory control system ● Identify an advantage of supervisory control over direct digital control ● Describe a Distributed control system ● Identify the advantages of DCS ● Identify some of the control functions of a distributed control system ● Explain DCS terminology ● Explain hardware requirements for distributed control systems ● Describe how control loops are implemented in a DCS ● Explain communications between modules and external devices ● Describe two types of data transmission ● Explain how signal integrity is maintained ● Define system interfacing ● Define communication protocols and their function in data transmission ● Name two primary types of human interface ● Describe DCS input devices and describe types of available displays.

# Maintaining Distributed Control Systems (ADC02)

**Prerequisites:** This lesson is designed for participants familiar with process operations, digital electronic theory, and test instruments and devices.

**Description:** This lesson introduces the general maintenance requirements of a distributed control system (I)CS). It covers troubleshooting techniques using DCS self-diagnosis and the various diagnostic displays available to the technician as well as safe and proper component replacement procedures for cards, modules and power supplies. The lesson also covers DCS peripheral equipment including disk and tape drives and uninterruptible power supplies (UPS).

**Objectives:** Identify proper tools and test equipment for troubleshooting ● Interpret diagnostic software from the operating console and the engineering workstation ● Demonstrate proper troubleshooting methods ● Identify typical communication malfunctions ● List symptoms of communication faults ● Identify a proper cable connection ● List indications of power supply failure ● Check power supply voltages ● List indications of workstation failure ● Identify 1/0 failures ● Demonstrate safe removal and replacement of cards ● Demonstrate proper replacement card set up ● Explain 1/0 module configuration ● Demonstrate safe power supply removal ● Set power supply voltages ● Explain how signal integrity is maintained ● Describe proper communication cable replacement ● Perform a redundancy check ● Clean a disk drive ● Explain the importance of and general procedure for backing up data and list UPS preventive checks.

# Electronic Maintenance Library (5 CD's)

*20-30 hours of training*

**This comprehensive INVOLVE® multimedia-training program was produced in association with the Instrument Society of America (ISA).** This five lesson program trains participants in Me maintenance of electronic instruments, including pressure, temperature, flow, level, and weight transmitters as well as transducers, recorders, annunciators, and analog electronic controllers.

**Audience**: This program is excellent for training for maintenance personnel and instrument technicians as well as for the multi-craft training needs of process and manufacturing facilities.

# Pressure and Temperature Transmitters (AEM01)

**Prerequisites:** This program is designed for participants familiar with process and control principles as well as basics of digital electronic theory and test procedures.

**Description:** This lesson introduces electronic transmitter maintenance focusing on pressure and temperature transmitters. The lesson describes the components of a typical pressure or temperature transmitter, their functions, adjustments, inspections, and repairs. Procedures for isolating the faulty component in a transmitter are also demonstrated.


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**Objectives:** Identify components in a disassembled electronic differential pressure or electronic temperature transmitter ● Test the power supply for the transmitter in an electronic pressure transmitter ● Adjust the sensor zero and replace the electronics module of the pressure transmitter ● Isolate malfunctions to either the sensor or circuitry portion of a differential pressure transmitter ● Verify that a sensor is properly grounded ● Swap circuit boards in a differential pressure transmitter ● Replace the sensor assembly of a DP transmitter ● Identify the faulty component in a thermocouple transmitter ● Test outputs and repair an RTD ● Swap a defective board to calibrate a malfunctioning RTD.

# Flow Transmitters (AEM02)

**Prerequisites**: This lesson is designed for participants familiar with electronic test procedures. An understanding of process operation is also required.
**Description:** This lesson introduces the inspection and repair of electronic flowmeters by demonstrating maintenance procedures for vortex shedding, turbine, magnetic, and mass electronic flowmeters. The lesson describes typical flow transmitter components, their functions, common malfunctions, and procedures for isolating a faulty component.

**Objectives:** Test and replace the amplifier unit, sensor, and bluff body of a vortex shedding flowmeter ● Test and replace ● The preamplifier unit, coil and other necessary components of a turbine flowmeter ● Test and replace the coil, electrodes, and circuit board in a magnetic flowmeter ● Jumper the appropriate terminals to simulate zero output and check the flowmeter output in an installed mass flowmeter ● Test and replace the sensor and circuit boards in an installed mass flowmeter.

# Level and Weight Transmitters (AEM03)

**Prerequisites:** This lesson is designed for participants familiar with basic mathematical operations including algebra.
**Description:** This lesson describes the operation, applications, and maintenance of ultrasonic, capacitance, conductivity, and radiation level detectors. The lesson also explains the functions and operation of weighing systems.
**Objectives:** Describe the applications and operation of ultrasonic level detectors and their use in both point and continuous measurement applications ● Troubleshoot and maintain ultrasonic level detection systems ● Describe the applications and operation of radiation level detectors and their use in both point and continuous measurement applications ● Explain the safety considerations when maintaining radiation level detectors ● Describe the applications and operation of capacitance and conductivity level detectors in both point and continuous measurement applications ● Recognize safety considerations for the use of level probes with flammable and/or explosive materials ● Identify the maintenance procedures for capacitance level detection systems ● Describe the applications and operation of a strain gage load cell as well as considerations for load cell calibration ● Describe the applications and operation of a belt conveyor scale as well as how to test and calibrate it.

# Transducers, Annunciators, Recorders (AEM04)

**Prerequisites:** This lesson is designed for participants familiar with calibration principles, process control, and control loops.
**Description**: This lesson teaches routine maintenance requirements and calibration procedures for transducers, recorders, and annunciators. The lesson provides a basic understanding of the functions of I/P, P/I, and E/I transducers, multipen and multipoint recorders, and annunciators. The lesson also outlines how to identify and troubleshoot problems in these instruments.
**Objectives:** Identify and describe the function of electronic transducers ● Identify how I/P transducers work ● Identify troubleshooting steps for pneumatic and electronic function on I/P transducers ● Identify the steps for continuity tests on I/P transducers ● Identify coil replacement steps for I/P transducers ● Identify calibration steps for P/I and E/I transducers, identify motor replacement steps for the chart drive on a multipen recorder ● Identify the function of drive gears on a multipen recorder and how to clean them ● Identify installation steps for a new drive cable on a multipoint recorder and check for proper operation ● Identify the function of drive wire resistors on multipoint recorders and how to clean and inspect them ● Calibrate multipen and multipoint recorders ● Define the function of annunciators and troubleshoot them.

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# Electronic Controllers (AEM05)

**Prerequisites:** This lesson is designed for participants familiar with process control and control loops.
**Description:** This lesson presents routine maintenance requirements and calibration procedures for electronic controllers. The lesson shows how controller circuitry works and how to adjust and calibrate each of its component sections: the display, the alarm circuitry, and the control circuitry.

**Objectives:** Identify the features and functions of controllers ● Describe and compare pneumatic and electronic controllers ● Identify the signal path through a control circuit ● Describe the function of resistors, comparators, proportional band amplifiers, integral amplifiers, differentiating amplifiers, summing amplifiers, and the transducer ● Visually identify indicators on electronic controllers as well as set point, process, output, and alarms ● Visually identify controls on electronic controllers as well as set point control, auto-manual selector switch, and manual/valve control ● Identify appropriate equipment and demonstrate procedures for calibrating and troubleshooting display indicators ● Identify appropriate test points and demonstrate procedures for calibrating and troubleshooting alarm indicators ● Identify appropriate equipment for calibrating control circuits and calibrate proportional, integral, and derivative zero on the control circuit ● Identify appropriate equipment for troubleshooting control circuits.

# Fundamentals of Industrial Measurement Library (4 CD's)

**This comprehensive INVOLVE® interactive multimedia training program was produced in association with the Instrument Society of America (ISA).** This four individual lesson program trains participants in the principles of process control and measurement.
**Audience**: This program is an excellent entry-level course for engineers, technicians, and operators as well as for the multicraft training needs of process and manufacturing facilities.

# Pressure Measurement (AFM01)

**Prerequisites:** This lesson is designed for participants familiar with basic mathematical operations including algebra.
**Description**: This lesson presents the basic principles of pressure measurement and applications of direct and inferred pressure measurement methods. Various pressure instruments are presented including manometers, mechanical pressure sensors, and transducers.
**Objectives:** Recognize the importance of the measurement and control of pressure ● Define pressure and determine the pressure exerted by a liquid ● Recognize the importance of sensor location in pressure measurement, calculate the force exerted by liquids ● Identify the effects of temperature change on the force exerted by a liquid ● Identify the factors which determine the force exerted by a gas ● Convert various units of pressure measurement to psig, psia, InH2O, and InHg using a conversion table ● Calculate differential pressure ● Recognize the effect of atmospheric pressure on pressure measurement ● State the principle of operation of closed and open manometers ● Identify the types of manometers and the considerations for their safe and effective use ● Describe the principle of operation for elastic elements ● Explain how the movement of a sensing element can be used to produce a pneumatic and electrical signal ● Describe the operation of mechanical to electrical transducers.

# Flow Measurement (AFM02)

**Prerequisites:** This lesson is designed for participants familiar with basic mathematical operations including algebra.
**Description:** This lesson describes the properties of fluids that are a factor in the measurement of their flow. In addition, the lesson explains how differential pressure measurements can be used to determine flow rate. Various types of flow measurement devices and their principles of operation are also discussed.
**Objectives:** Recognize the effect of temperature and pressure on the density and volume of a liquid and a gas ● Describe the effects of temperature on viscosity and how viscosity affects flow ● Describe laminar flow, turbulent flow, and transitional flow ● Describe the application of the Reynolds Number to flow measurement ● Identify variables that affect mass flow rate ● Describe how static pressure is converted to kinetic energy ● Explain Bernoulli's law as it applies to differential pressure flow measurements ● Explain the necessity of an expansion factor


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in differential pressure flow measurements of a gas ● Describe how an orifice-type differential pressure flow device measures flow ● Explain how a beta ratio is determined and its
application to flow measurements ● Identify the location of high and low pressure taps in an orifice run ● Describe the design and operation of Venturi tube, flow nozzle, and Pitot tube differential pressure flow devices ● Explain the difference between closed and open systems ● Describe the design and operation of weir and flume head-type differential pressure flow devices ● Describe the design and operation of vortex shedding, magnetic, ultrasonic, rotary vane, turbine, and Coriolis mass flowmeters ● Describe the operational principles of positive displacement flowmeters ● Describe how an inferential mass flow measurement differs from a true mass flow measurement.

# Temperature Measurement (AFM03)

**Prerequisites:** This lesson is designed for participants familiar with basic mathematical operations including algebra.
**Description:** This lesson presents the basic principles of temperature measurement and the application of temperature measuring instruments. Various temperature-measuring instruments are discussed including thermometers, pyrometers, thermocouples, resistance temperature detectors, and thermistors.
**Objectives:** Recognize the importance of temperature measurement and control ● Identify the principle of kinetic energy with a graph of molecular movement ● Identify four scales used to indicate temperature ● Define heat transfer in terms of conversion, conduction, and radiation ● Define response time, stem loss, and radiation error ● Identify the effect that inserting a sensor in a thermowell will have on the sensor's temperature measurement and its response time ● Identify the effect that thermal shunting will have on temperature measurement ● Describe the principles of operation for a liquid in glass thermometer ● Thermal bulb, and a bimetallic thermometer ● Describe the principle of operation for an optical and ratio pyrometer ● Identify the reference and measuring junctions in a drawing representing a thermocouple ● Identify the negative wire in a type J thermocouple ● Identify the components of a thermocouple assembly when a thermocouple is inserted in a thermowell ● Explain how a thermopile is used to produce greater output in response to smaller temperature change ● Identify the use and application of thermocouples joined in parallel ● State the principle of operation for a resistance temperature detector ● Identify the bridge circuit's operation in an RTD to measure temperature ● Identify the effect strain will have on a resistance temperature detector ● Identify the type, design considerations, and strain on various types of RTDs ● Identify a voltage divider circuit's operation in a thermistor circuit to measure temperature ● State the principle of operation for a thermistor.

# Level Measurement (AFM04)

**Prerequisites:** This lesson is designed for participants familiar with basic mathematical operations including algebra.
**Description:** This lesson describes the fundamentals of level measurement and the sensors employed. Applications for both direct and indirect level measurement are covered including float-type devices, hydrostatic head and differential pressure measurements, as well as electrical, ultrasonic, and radiation instruments.
**Objectives:** Recognize the importance of measuring and controlling level ● Describe what an interface is and list some of the types of interfaces that may be measured for level indication ● List common measurement units of level ● Define direct and indirect level measurement and some types and applications of these methods ● Define continuous level
and point level measurement ● Describe how sight glasses operate to measure liquid level ● Describe how dipsticks, weighted lines, and float-type instruments can be used to gage level ● Define hydrostatic head pressure and explain how it can be used to measure the height of liquid ● Calculate the height of the liquid in inches with a head pressure and specific gravity ● Describe configurations using hydrostatic head to measure level in open tanks ● Describe how differential pressure can be used to measure level in closed-tank applications using a dry or wet leg ● Explain how level can be measured using electrical capacitance or resistance ● Describe two ways the level of granular solids and powders can be measured ● Describe some non-invasive level measurement methods that use ultrasonic and radiation detectors ● Describe the basic operation of one type of fiber optic level measurement instrument for point level measurement.


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# Industrial Process Control Library (2 CD's)

*8-12 hours of training*

**This comprehensive INVOLVE® interactive multimedia training program was produced in association with the Instrument Society of America. (ISA)**.

This two lesson program trains participants in the concepts and principles of process control modes.

**Audience**: This program is an excellent entry-level course for control practitioners as well as for the multi-craft training needs of process and manufacturing facilities.

## Single Loop Control (AIP01)

**Prerequisites:** This lesson is designed for participants familiar with measurement fundamentals. An understanding of algebra is also recommended.

**Description:** This lesson presents the principles of single-loop control and the applications of feedback control in the industrial environment. Also introduced are various control modes including on/off, proportional, integral, and derivative control.

**Objectives:** Define and site industrial control ● Define process variable ● Compare manual and automatic process control ● Adjust the set point on a pictorial representation of an industrial controller ● Identify the controlled, measured, and manipulated variables of a heat exchanger system ● Define deviation ● Identify the system response for various control modes ● Define load change ● Identify the elements of process control ● Identify the action of the final control element of various control systems ● Identify the dead zone or dead band on an on/off control response curve ● Compare and contrast the action of a final control element in an on/off control ● System with a proportional control process ● Identify reverse- or direct-acting control with an example of measurement and subsequent output response ● Define proportional control in relation to response error ● Determine the setting of the controller's proportional band and gain on a pictorial representation of process control action ● Identify offset on an example of proportional only control ● Define integral control in relation to error signal ● Identify minutes per repeat and repeats per minute with an example of the units used in integral control ● Define reset wind-up on a process response curve for an integral controller ● Identify the effects of reset wind up on the
elements of process control on a heat exchange system ● Define derivative process control in relation to error signal.

## Multiple Loop Control (AIP02)

**Prerequisites:** This lesson is designed for participants familiar with single-loop control. An understanding of pressure, temperature, level, and flow measurement as well as basic algebra is also recommended.

**Description:** This lesson explains the application of multiple-loop control strategies to industrial process control systems. The lesson also explains the operation of several types of digital process control systems.

**Objectives:** Identify the benefits of advanced process control strategies ● Compare feedback and feedforward control ● Explain the principles and applications of a feedforward control system ● Explain the principles and identify the benefits of cascade control ● Discriminate between wild and controlled flows in a ratio control system ● Explain the principles and applications for ratio control ● Explain the principles and application of adaptive and
selective control ● Identify the method of process control used in direct digital, supervisory, and distributed control systems.

# *Instrument Calibration Library (5 CD's)20-30 hours of training*

This comprehensive INVOLVE® interactive multimedia training program was produced in association with the Instrument Society of America. (ISA). This five lesson program trains participants to calibrate pressure, differential pressure, temperature, flow, and level instruments.

**Audience**: This program was designed for instrument technicians and electricians as well as for the multi-craft training needs of process and manufacturing facilities.

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# Calibration Principles (AIC01)

**Prerequisites:** This lesson is designed for participants familiar with instruments and their functions within a typical feedback/control loop. An understanding of algebra is also recommended.
**Description:** This lesson introduces basic concepts of instrument calibration. The lesson explains the characteristics of proper instrument performance as well as how to identify common instrument errors. In addition, the steps in a typical calibration procedure are demonstrated.
**Objectives:** Define calibration ● Recognize if an instrument is properly calibrated by examining the instrument input and output ● Explain how calibration affects quality, productivity, and safety ● Identify conditions when calibration is performed such as at an installation, periodic scheduled maintenance, in response to process deviation, and after repair or change in mounting position ● Recognize accuracy and precision ● Identify zero shift, span error, combined zero shift and span error, and non-linearity with a pattern of instrument readings on an input/output graph or calibration data sheet ● Identify the basic elements of a calibration set-up ● Identify the input values for a five point ● Calibration check as a percent of the instrument's range.

# Calibrating Pressure and Differential Pressure Instruments (AIC02)

**Prerequisites:** This lesson is designed for participants familiar with the basic principles of calibration including the steps of a calibration procedure, common instrument errors, and the standards for instrument performance. An understanding of algebra is also recommended.
**Description:** This lesson demonstrates the necessary steps for calibrating pressure instruments. The lesson also identifies procedures and set-up equipment for pressure calibration. Emphasis is placed on selection of the appropriate test instruments and interpretation of readings.
**Objectives:** Set up a pressure transmitter, differential pressure transmitter, and a pressure gage for calibration with the appropriate input and output test equipment, proper connections, and mountings ● Perform a five-point calibration check on an analog electronic pressure transmitter, a differential pressure transmitter, and a pressure gage ● Identify zero shift, span error, combined error, and nonlinearity ● Properly adjust pressure instruments to eliminate errors ● Use a digital interface device to re-range a smart pressure transmitter.

# Calibrating Temperature Instruments (AIC03)

**Prerequisites:** This lesson is designed for participants familiar with the basic principles of calibration including calibration procedures, common instrument errors, and the standards for instrument performance. An understanding of algebra is also recommended.
**Description:** This lesson teaches basic procedures for checking the calibration of thermocouples and RTDS, as well as for calibrating temperature instruments including thermocouple transmitters and RTD transmitters. Procedures using thermocouple and RTD tables are presented in addition to calibration steps using a digital temperature calibrator.
**Objectives:** Identify common test equipment used as measurement standards for calibration of temperature instruments ● Property set up and connect the measurement standards for calibration of temperature instruments ● Identify the proper thermocouple or RTD table for the sensor in the loop and use the tables in calibration ● Check the calibration of thermocouples and RTDs ● Calibrate an analog electronic temperature transmitter whose input is provided by a thermocouple or an RTD ● State safety precautions for calibrating temperature instruments in the field.

# Calibrating Flow Instruments (AIC04)

**Prerequisites:** This lesson is designed for participants familiar with the basic principles of calibration including procedures, identifying instrument errors, and the standards for instrument performance. An understanding of algebra is also recommended.
**Description:** This lesson demonstrates procedures for calibration of flow instruments. The lesson specifically explains calibration of differential pressure transmitters, magnetic flowmeters, vortex shedding flowmeters, and mass flowmeters. Emphasis is placed on the proper set-up for calibration and the selection of the proper test equipment.
**Objectives:** Observe the correlation between differential pressure and flow rate ● Identify and set up the measurement standards for calibrating a differential pressure transmitter ● Perform a five point check on a differential


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pressure transmitter ● Interpret the results and correct instrument errors ● Set up a square root extractor for calibration and adjust its zero ● Observe how a magnetic flowmeter generates the output voltage as a result of the input voltage ● Calibrate a magnetic flowmeter ● Observe how a vortex shedding flowmeter
generates output resulting from input ● Set the course span jumpers correctly and determine proper calibration of a vortex shedding flowmeter ● Connect the interface device to the smart mass flowmeter ● Set the interface device to the smart mass flowmeter ● Modify the upper and lower range values ● Download the new information to the transmitter ● And test the mass flowmeter for autozero.

## Calibrating Level Instruments (AIC05)

**Prerequisites:** This lesson is designed for participants familiar with the basic principles of calibration including procedures, common instrument errors, and the standards for instrument performance. An understanding of algebra is also recommended.
**Description:** This lesson demonstrates the steps for calibrating level instruments. Specifically, the lesson shows set-up procedures for differential pressure transmitters and electronic displacement level transmitters in a variety of applications.
**Objectives:** Identify the importance of properly calibrated level instruments ● Describe how hydrostatic pressure can be used to sense liquid level ● Determine the input range for calibrating a differential pressure transmitter for use in a specific level application ● Select the input and output measurement standards for calibrating hydrostatic level
instruments ● Calibrate a differential pressure transmitter used in an open tank or dip pipe, a closed tank with dry leg, and closed tank with wet leg ● Define elevated or suppressed zero and determine the amount of zero suppression or elevation in a given hydrostatic pressure level gaging system ● Describe how an electronic displacement level transmitter uses buoyant force to sense liquid level ● Select the input standards for calibrating an electronic displacement level transmitter for liquid-vapor and liquid-liquid interface applications ● Select the output equipment for calibrating an electronic displacement transmitter ● Calibrate an electronic displacement level transmitter for liquid-vapor and liquid-liquid interface applications.

# Instrumentation and Control Safety Library (3 CD's)

*12-18 hours of training*
**This comprehensive INVOLVE® interactive multimedia training program was produced in association with the Instrument Society of America. (ISA).** This three lesson program trains participants in personnel safety, safe practices for working with hazardous materials, and the safe use of instruments in hazardous environments.
**Audience**: This program is excellent for training instrument technicians as well as for the multi-craft training needs of process and manufacturing facilities.

## Personnel Safety (AIS01)

**Prerequisites:** This lesson is designed for participants with an understanding of industrial process control and a working knowledge of the elements in single-loop and multiple-loop control.
**Description:** This lesson trains participants in precautions for ensuring their personal safety while working in four types of hazardous locations: high places, outdoors, confined spaces,
and open trenches. It also covers types and applications of personal protective gear, including safety harnesses, atmospheric monitors, and breathing aids.
**Objectives:** Describe how attitude and awareness can affect personal safety ● Describe safety considerations for working in high places, open trenches, outdoors, and in confined spaces ● Explain when and how personal and portable oxygen monitors, combustible gas/vapor monitors, and portable radiation monitors are used ● Identify the correct personal protection gear to wear in different hazardous locations ● Describe the conditions under which air-purifying respirators are used ● Describe the two main types of air-supplying respirators and describe the conditions under which each is used ● Describe three types of regulators used in air-supplying respirators and their applications ● Describe the checks that need to be made to respirators to ensure their proper operation ● Describe proper checks to make on safety belts/harnesses.

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# Working with Hazardous Materials (AIS02)

**Prerequisites:** This lesson is designed for participants with an understanding of industrial process control and personnel safety, as well as a working knowledge of the elements in single-loop and multiple-loop control.
**Description:** This lesson trains participants to identify and properly handle hazardous materials in the workplace. Characteristics and warning labels for corrosives, oxidizers, flammables, and toxic materials are described.
**Objectives:** Define hazardous materials ● Identify the importance of safety in handling hazardous materials ● Describe toxic materials ● Describe flammable and combustible materials ● Describe oxidizers ● Describe explosive materials ● Describe compressed gases ● Explain the Right-to-Know concept ● Identify a safety warning label ● Interpret a material data safety sheet ● Demonstrate precautions to take when working with hazardous process lines ● Given a component, describe the necessary decontamination process ● Describe how poor housekeeping can affect safety ● Describe proper collection and disposal methods for hazardous materials ● Describe proper re-use of hazardous materials ● Demonstrate the correct response to an inadvertent release of a hazardous material ● Demonstrate the correct response to exposure to hazardous materials.

# Instruments in Hazardous Environments (AIS03)

**Prerequisites:** This lesson is designed for participants with an understanding of industrial process control, personnel safety and working with hazardous substances, as well as a working knowledge of the elements in single-loop and multiple-loop control.
**Description:** This lesson explains the characteristics and importance of intrinsically safe, explosion-proof, and purged and pressurized systems. Installation and maintenance considerations for safety systems are taught, including project planning, wire runs, terminations, and grounding.

**Objectives:** Identify the causes of explosions ● Identify the components of the combustion triangle ● Describe how protective measures can reduce the probability of explosion ● Describe nonincendive, encapsulation, and oil-filled safety methods ● List and define area classification descriptions ● Define intrinsic safety and identify intrinsically safe components and installations ● Identify the principles of intrinsic safety ● Define the function of a barrier ● Identify process components that require certification for intrinsic safety ● Demonstrate the ability to interpret documentation for proper intrinsic installation ● Identify intrinsically safe wire runs ● Explain the purpose of conduit seals ● Identify proper terminations for intrinsically safe connections ● Describe the installation and maintenance procedures associated with intrinsically safe systems ● List maintenance conditions for intrinsically safe installations ● Identify the correct tools and equipment to use on intrinsically safe installations ● Identify the proper classifications and ratings for explosion-proof materials ● Demonstrate the proper handling of explosion-proof covers, housings, and fittings, and the minimum precautions needed prior to the maintenance of explosion-proof equipment ● Describe purging and pressurization.

# Interpreting Process Control Diagrams Library (1 CD)

*4-6 hours of training*
**This comprehensive INVOLVE® interactive multimedia training program was produced in association with the Instrument Society of America. (ISA)**. This one lesson program trains participants how to interpret process and instrument diagrams.
**Audience**: This program is excellent for training instrument technicians and electricians as well as for the multi-craft training needs of process and manufacturing facilities.

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# Interpreting Process Control Diagrams (AIPCD)

**Prerequisites:** This lesson is designed for participants familiar with instruments and control functions.

**Description:** This lesson introduces the common instrument and line symbols and notations used on process control and loop diagrams. The interpretation of process control and loop diagrams is presented as well. Emphasis is placed on identifying the functions of components within the process control system.

**Objectives:** Identify the function, measured variable, location and accessibility, and loop identification of an instrument given its symbol and tag number ● Identify the type of connection between an instrument and the process to which it's connected when given a tag number ● Identify signal line types (pneumatic, electrical, capillary, or internal software link) ● Identify the type of valve actuator (diaphragm, motor, solenoid, or piston) when given a symbol ● Describe the information available in a typical process control diagram, title block, revision list, materials list, and notes block ● Describe the functional operation of the systems represented in typical process control diagrams ● Understand the function of loop diagrams and their relationship to process control diagrams ● Understand the purpose of each of the four areas of a typical loop diagram

● Identify the location and type of each instrument port connection, junction box, and power source as well as the controller action for the instruments in a loop diagram ● Describe the functional operation of the systems represented in a typical loop diagram.

## *Volume Equivalents*

| Unit | US.gallon | UK.gallon | $inch^3$ | $ft^3$ | liter | $m^3$ | barrel |
|---|---|---|---|---|---|---|---|
| US.gallon | 1 | 0.83267 | 231 | 0.13368 | 3.7853 | 0.00378 | 0.02381 |
| Im.gallon | 1.2009 | 1 | 277.42 | 0.16054 | 4.5459 | 0.00455 | 0.02859 |
| $inch^3$ | 0.004329 | 0.003604 | 1 | 0.000579 | 0.0164 | 0.000016 | 0.0001 |
| $ft^3$ | 7.4805 | 6.2288 | 1728 | 1 | 28.316 | 0.02832 | 0.17813 |
| liter | 0.26418 | 0.21997 | 61.024 | 0.0353 | 1 | 0.001 | 0.00629 |
| $m^3$ | 264.17 | 219.97 | 61023.74 | 35.3147 | 1000 | 1 | 6.2899 |
| barrel | 42 | 34.977 | 9702 | 5.614 | 158.983 | 0.15876 | 1 |

## *Power Equivalents*

| Unit | lbf·ft/s | Btu/s | W,J/s | hp | kW |
|---|---|---|---|---|---|
| lbf·ft/s | 1 | 0.00128 | 1.35582 | 0.00182 | 0.00135 |
| Btu/s | 778.1551 | 1 | 1055.0368 | 1.41483 | 1.0550 |
| W,J/s | 0.73756 | 0.00095 | 1 | 0.00134 | 0.001 |
| hp | 550 | 0.7068 | 745.7 | 1 | 0.74570 |
| kW | 737.56 | 0.948 | 1000 | 1.341 | 1 |

## *Energy Equivalents*

| Unit | lbf·ft | $psia \cdot ft^3$ | kJ | Btu | cal | kWh |
|---|---|---|---|---|---|---|
| lbf·ft | 1 | 0.00694 | 0.00135 | 0.0013 | 0.00323 | 0.00000038 |
| $psia \cdot ft^3$ | 144.000 | 1 | 1.95237 | 0.18504 | 0.46632 | 0.000054 |
| kJ | 737.562 | 0.51219 | 1 | 0.094782 | 0.23884 | 0.000028 |
| Btu | 778.169 | 5.40395 | 10.55053 | 1 | 2.51994 | 0.00029 |
| cal | 308.8 | 2.14445 | 4.1868 | 0.39683 | 1 | 0.00012 |
| kWh | 2,573,333.33 | 18439.03395 | 34890 | 3412.14 | 8598.49 | 1 |

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## *Velocity Equivalents*

| Unit | mm/s | ft/min | cm/s | ft/s | m/s |
|---|---|---|---|---|---|
| **mm/s** | 1 | 0.19685 | 0.1 | 0.003281 | 0.001 |
| **ft/min** | 5.8 | 1 | 0.508 | 0.016667 | 0.00508 |
| **cm/s** | 10 | 1.9685 | 1 | 0.032808 | 0.01 |
| **ft/s** | 304.8 | 60 | 30.48 | 1 | 0.3048 |
| **m/s** | 1,000 | 196.85 | 100 | 3.2808 | 1 |

## *Mass Equivalents*

| Unit | pound | ounce | gram | kg | slug | stone | tonne |
|---|---|---|---|---|---|---|---|
| **pound** | 1 | 16 | 453.6 | 0.453597 | 0.031 | 0.0135 | 0.0004536 |
| **ounce** | 0.0625 | 1 | 28.3495 | 0.028349 | 0.0019 | | |
| **gram** | 0.0022 | 0.0353 | 1 | 0.001 | | | |
| **kg** | 2.2046 | 35.274 | 1,000 | 1 | 0.0685 | 0.157 | 0.001 |
| **slug** | 32.174 | 514.785 | 14,593.9 | 14.5939 | 1 | 2.29825 | 0.014594 |
| **stone** | 13.988 | 223.99 | 6,350.0 | 6.35 | 0.4351 | 1 | 0.00635 |
| **tonne** | 2,204.6 | | | 1,000 | 68.5213 | 157.48 | 1 |

| Unit | GPM(US) | GPM(UK) | $ft^3$/min | $ft^3$/sec | $m^3$/hr | $m^3$/min | liter/sec |
|---|---|---|---|---|---|---|---|
| **GPM(US)** | 1 | 0.8327 | 0.1337 | 0.00223 | 0.2271 | 0.003785 | 0.06308 |
| **GPM(UK)** | 1.201 | 1 | 0.1605 | 0.002676 | 0.27275 | 0.004545 | 0.0758 |
| **$ft^3$/min** | 7.481 | 6.229 | 1 | 0.01667 | 1.699 | 0.02832 | 0.4719 |
| **$ft^3$/sec** | 448.83 | 373.7 | 60 | 1 | 101.94 | 1.699 | 28.32 |
| **$m^3$/hr** | 4.403 | 3.666 | 0.5886 | 0.00981 | 1 | 0.01667 | 0.2778 |
| **$m^3$/min** | 0.2642 | 0.22 | 35.3147 | 0.5886 | 60 | 1 | 16.667 |
| **liter/sec** | 15.85 | 13.2 | 2.119 | 0.0353 | 3.6 | 0.06 | 1 |