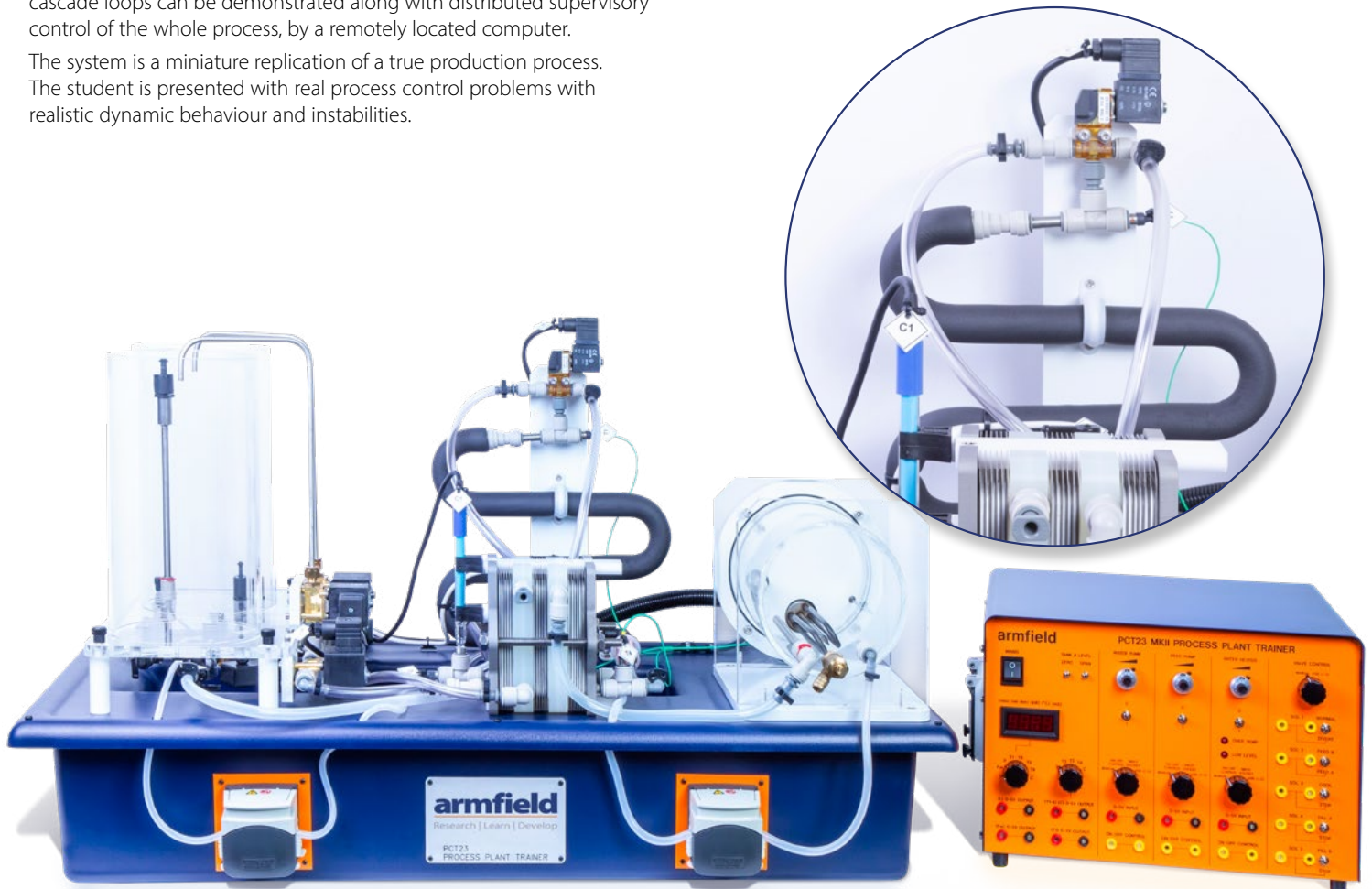


Process Plant Trainer – PCT23MKII

The Armfield Process Plant Trainer - PCT23MKII can be used to demonstrate a complete range of process control methods and strategies. Manual control and single feedback loops through to sophisticated cascade loops can be demonstrated along with distributed supervisory control of the whole process, by a remotely located computer.

The system is a miniature replication of a true production process. The student is presented with real process control problems with realistic dynamic behaviour and instabilities.

**PID OR PROGRAMMABLE CONTROLLERS
CONTROL AND/OR DATA LOGGING USING A PC**



Key features

The Armfield Process Plant Trainer is a miniature version of a real industrial process, having typical problems of dynamics and stability for which control strategies must be devised and operated.

The following process characteristics are incorporated:

- ▶ Multiple inputs and outputs
- ▶ Presence of dead time
- ▶ Recycling to minimise energy needs
- ▶ Alarms with corrective actions
- ▶ Operational sequencing from start up to shut down

The trainer allows the user to investigate various control techniques associated with process plant. These techniques range progressively from single loop analogue control through to multi loop PLC systems and ultimately to distributed supervisory control of the whole process by a remotely located PC station.

The Process Plant Trainer incorporates an electrical console which provides access to the various signals associated with measurement and control of the process allowing a variety of control possibilities:

- ▶ Manual operation
- ▶ Data logging using a PC or chart recorder
- ▶ Manual control via a PC using a mimic diagram
- ▶ Direct digital control using a PC
- ▶ Use of industrial, PID or programmable controllers
- ▶ Use of customer-provided controllers
- ▶ Use of serial communications for supervisory control of individual controllers (SCADA)

Computer software is supplied with the Process Plant Trainer which allows control and/or data logging using a PC.

Description

The PCT23MKII is a bench top process control system, comprising a process unit mounted on an ABS plinth, an electrical control console, and control software, which can be run on any Windows PC with a spare USB port.

a) Process Unit

The process is modelled on an industrial high temperature short time (HTST) pasteurisation process. In this process the product stream has to be kept at a predetermined temperature for a minimum time, usually for bacteriological purposes. This is effected by the use of a holding tube, which delays the product stream, thus posing particular process control problems and introducing the concept of 'dead time'.

Other reasons why the HTST process is a particularly suitable basis for teaching process control are the use of a three stage heat exchanger (recycle, heating and cooling) and the use of a divert valve to reject inadequately treated product. Again these important industrial principles pose real process control problems and help maintain the students' interest.

Further process control problems are illustrated by the use of two feed tanks, with different level sensor types. Solenoid driven valves control the filling and emptying of these tanks. These enable different level control strategies to be developed and provide startup and shutdown operational sequencing capability.

The unit includes a wide range of instrumentation for temperature and flow measurement as well as a conductivity sensor, enabling simple process concentration experiments to be performed.

The unit comprises:

- ▶ Feed system with peristaltic pump
- ▶ Water heating unit with peristaltic pump
- ▶ Water cooling system
- ▶ Plate heat exchanger with holding tube
- ▶ Flow sensor in feed line
- ▶ Conductivity sensor
- ▶ Four temperature sensors
- ▶ Level sensor in product tank
- ▶ High/low level switches in washing/reagent tank
- ▶ 2-way solenoid valves for filling feed tanks and cooling water to exchanger
- ▶ 3-way solenoid valves for selecting feed tank and diverting waste product
- ▶ Connections to the electrical console

b) Control Console

The control console provides the electrical interface and signal conditioning for the process module. It also includes a USB interface for a Windows® computer. The process module sensor outputs can be displayed in engineering units on an integral LED display. The outputs are also available for external monitoring.

The drive signals to the process module can be selected as either manual control from the front panel, control from a PC via the USB, on/off control from an external source (eg the Armfield PCT19BR PLC) or analogue control from an external source (eg the Armfield PCT20H PID). The source signals for both pumps and the heater are individually selectable.

Electrical faults may be introduced into any of the low voltage measurement or control signals by a fault emulator installed in the electrical console. Faults may be inserted individually or in combination to suit the student's ability. The quick release fittings used throughout the process enable faults to be introduced into the process pipework.

The unit comprises:

- ▶ Product feed pump speed control
- ▶ Heating fluid pump speed control
- ▶ Heater power measurement and control
- ▶ Temperature (x 4), flow, level & conductivity measurement
- ▶ Digital inputs/outputs (from switches/to solenoid valves)
- ▶ Simultaneous connection of all signals to PCT19BR via 50 way IDC connector or PC via USB port
- ▶ Front panel sockets for connection to accessories, in particular industrial controllers and chart recorder



PCT23MKII Control console side switches

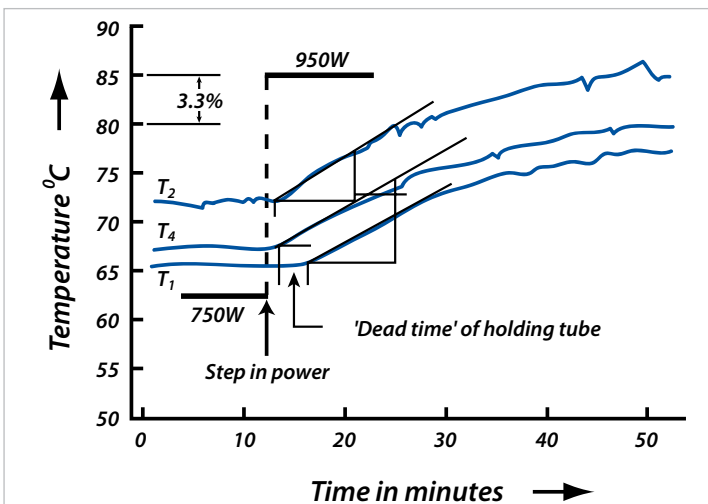


Fig 1: Open loop temperature responses to a step in change (in power). Use of a 'reaction curve' method to obtain optimum P+I+D settings for a process temperature (T_1 , T_2 and T_3) to control the power to the heater vessel. T_1 = Process temperature after holding tube, T_2 = Hot water circulating temperature, T_3 = Process temperature before holding tube

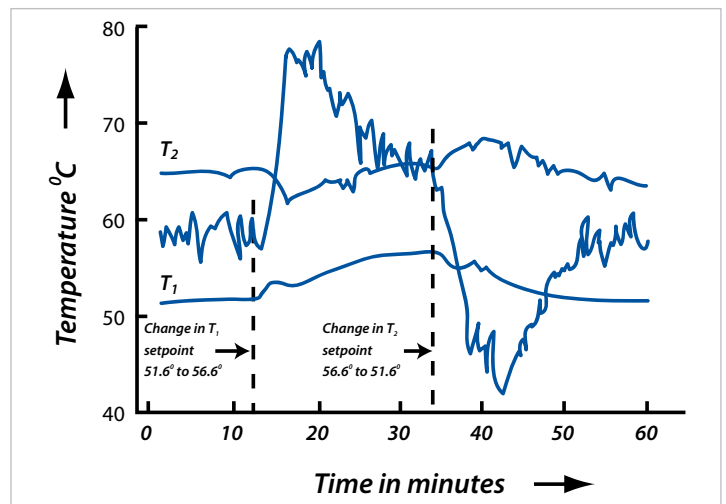


Fig 3: Dual loop control using Windows software

- Product temperature T_1 controlling hot water circulation rate
- Hot water temperature T_2 controlling heater power (PWR)

Note reaction between T_1 , T_2 and PWR as a result of setpoint change to T_1 (up 5°C then down 5°C).

Description

c) Software

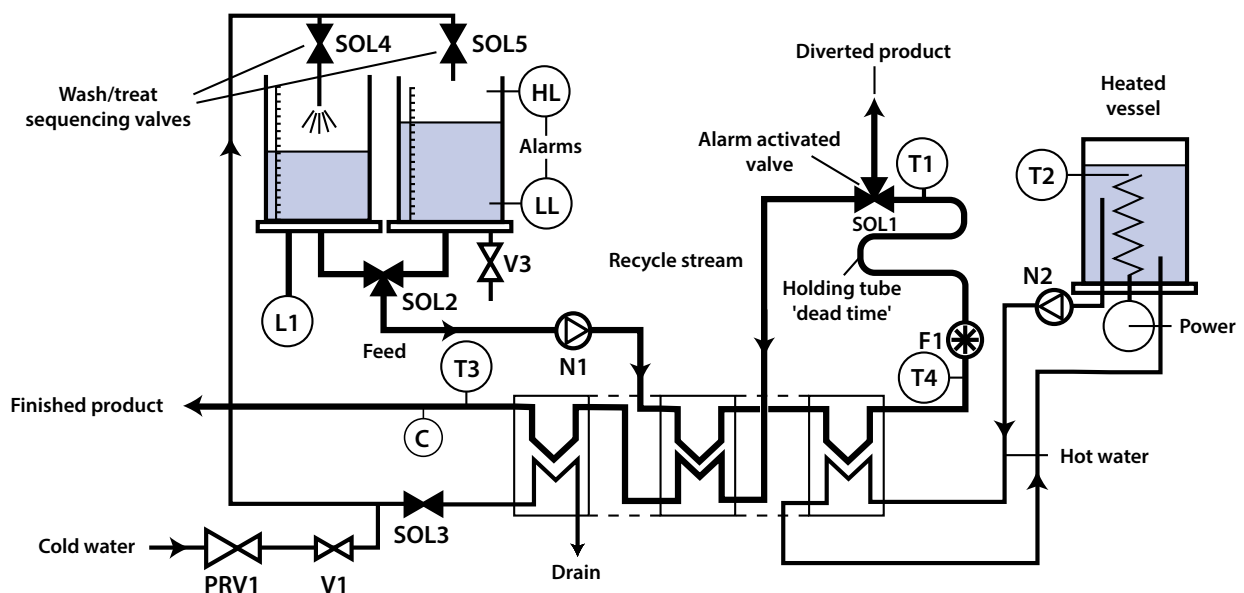
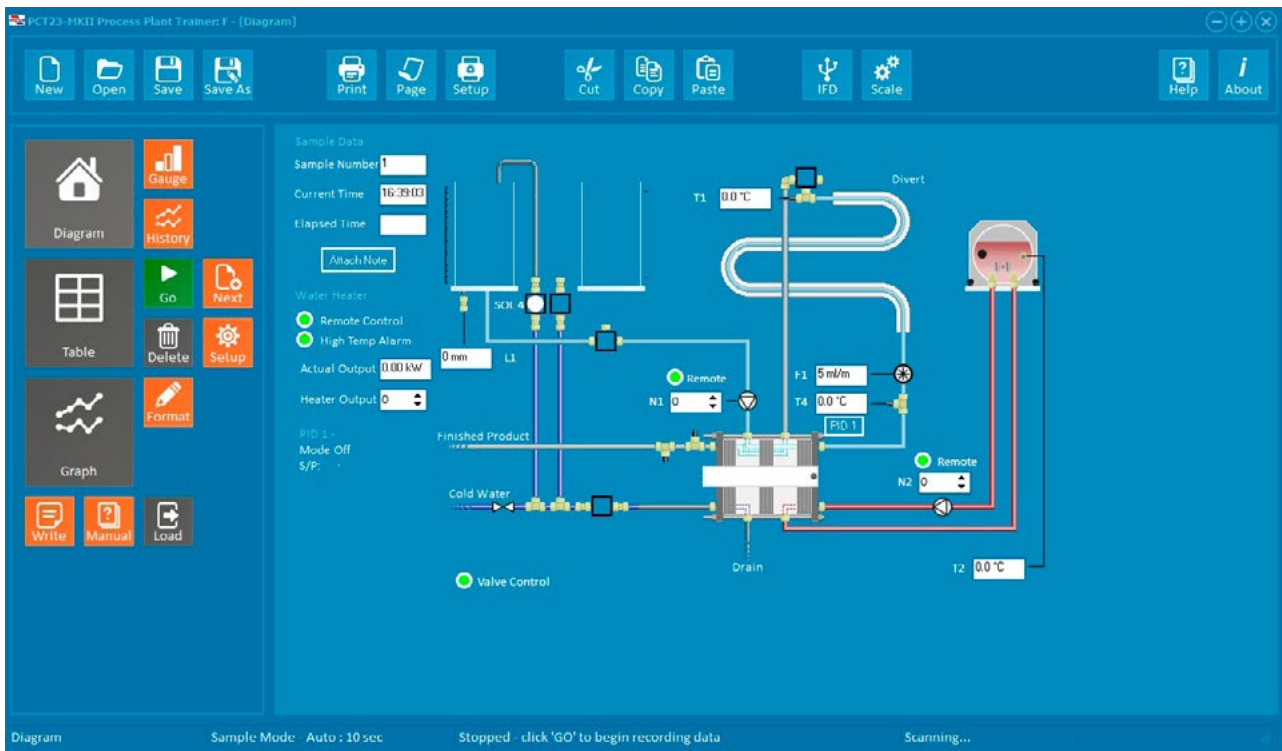
Included in the basic equipment supply is an advanced educational software package, which implements the control functions. The software displays a real time process mimic diagram and includes PID control algorithms, with user control over the key parameters. A number of predefined student exercises are implemented, such as alarm actions and acknowledgements, different single PID loops, cascade and multiple PID loops.

Included in the software is a sophisticated data logging and graphical display capability. This capability can be used even when the control signals are derived externally or manually. The data can be saved and recalled, or exported in Microsoft® Excel format.

Other facilities included in the software are a series of presentation screens to aid in the setting up, using the equipment, analysing the results, etc. This is backed up by a comprehensive help system.

Advanced users may wish to produce their own control software using packages such as LabVIEW™, MatLab or 'C'. This is possible using the USB interface on the PCT23 as the low level software driver (DLL) is accessible and interfacing instructions are provided.

For more advanced use, an optional software package has been developed for use with the Armfield PCT19BR to demonstrate SCADA. This package (order code PCT23SCADA) enables the PLC to control the process and extracts the data from the PLC via an RS232 connection. The PLC data is then displayed on the mimic diagram, giving the PC the supervisory role of the SCADA implementation.



Process flow diagram

Experimental content - PCT23

Practical training exercises

The Armfield PCT23MKII Process Plant trainer is designed to cover course topics ranging from a first introduction to the subject of process control through to demonstrations of the latest advanced techniques including the use of online mathematical models.

Plant Monitoring using a PC - Gaining familiarity with computer-based mimic diagrams for monitoring process variables: level, temperatures, flows and power

Calibration of Sensors - To calibrate the level sensor installed on the Process Plant Trainer

Process Dynamics I

- ▶ **Steady State Operation (Direct Heating)** - Introducing a first order system and the achievement of steady state by investigating the hot water tank characteristics (observing the effect of constant direct heating on the temperature in the hot water tank)
- ▶ **Indirect Heat Exchange** - Demonstrating indirect heating using a plate heat exchanger
- ▶ **Dead Time** - Demonstration of the phenomenon of dead time
- ▶ **Step Changes** - Measuring the response of a system (the plate heat exchanger) to step changes
- ▶ **Heat Transfer Losses** - To calculate heat transfer losses for the system

Process Dynamics II

- ▶ **Interaction** - Demonstrating the interaction between different loops in the system. Understanding how changing one process variable (e.g. flow rate) affects all the others (eg. temperatures)
- ▶ **Heat Regeneration** - From both environmental and economic viewpoints, recycling or regeneration of energy within the process is desirable. The heat exchanger on PCT23 is equipped with a regeneration section where incoming cold feed is preheated by outgoing hot product
- ▶ **Indirect Cooling** - In some situations, the finished product will need to be cooled further for final storage even after giving up energy in the regeneration section of the heat exchanger. The heat exchanger on PCT23 is equipped with a cooling section where outgoing product can be indirectly cooled using cold water (or chilled water)

- ▶ **Process Duty** - Understanding process duty and temperature differentials in the heat exchanger
- ▶ **PID Control of Level using Software** - Introduction to level control using a PC (single loop PID controller in software)
- ▶ **PID Control of Flow using Software** - Introduction to flow control using a PC (single loop PID controller in software)
- ▶ **PID Control of Temperature using Software** - Introduction to temperature control using a PC (single loop PID controller in software)
- ▶ **PID Control of Conductivity using Software** - To control the conductivity of the final product by adding a salt solution to the feed
- ▶ **Indirect PID Control of Temperature** - To demonstrate single loop PID control
- ▶ **PID Control of Temperature with Dead Time** - To demonstrate single loop PID control, with product temperature controlling heater power
- ▶ **PID Control with Alarm Driven Disturbances** - To demonstrate the effect on control action of including an alarm-activated diverter valve
- ▶ **Controller Optimisation** - Determining the ideal control parameters for a simple system (single loop, temperature to heater power)
- ▶ **Controller Optimisation with Dead Time** - Determining the ideal control parameters for a simple system with dead time (single loop, temperature to heater power)
- ▶ **Two Loop Cascade Control** - To demonstrate cascade control, whereby product temperature controls hot water temperature set point, which in turn controls heater power
- ▶ **Two Loop Control and Interaction** - To demonstrate the effect on process response of two separate PID control loops which interact
- ▶ **Three Loop Control** - To demonstrate multivariable control with interacting and non-interacting loops
- ▶ **Fault Finding and Diagnostics** - Fault simulation and diagnosis by the instructor switching out selected signals

With optional PCT20H Industrial controller

- ▶ External Level Controller Setup
- ▶ External On/Off Level Control
- ▶ External Time-Proportioned Level Control
- ▶ External PID Level Control
- ▶ External Flow Controller Setup
- ▶ External On/Off Flow Control
- ▶ External Time-Proportioned Flow Control
- ▶ External PID Flow Control
- ▶ External Temperature Controller Setup
- ▶ External On/Off Temperature Control
- ▶ External Time-Proportioned Temperature Control
- ▶ External PID Temperature Control
- ▶ Alarm Functions
- ▶ Comparison of Control Requirements
- ▶ Manual Tuning of a PID Controller
- ▶ Automatic Tuning of a PID Controller

With optional PCT19BR Industrial PLC Unit

- ▶ **Sequencing Plant Operation using a PLC** - Using a PC as supervisor to control the process via the PCT19BR Industrial Programmable Logic Controller.

With optional PCT23SCADA Software

- ▶ **Introduction to Scada** - To demonstrate supervision of the Industrial Controller PCT20H by PC based software - an introduction to SCADA with serial communications from a remote PC to and from the controller



PCT19BR Industrial PLC Unit



PCT20H Industrial Controller

Requirements

Scale



Electrical supply:

PCT23MkII-A: 220-240V/1ph/50Hz

PCT23MkII-B: 120V/1ph/60Hz

PCT23MkII-G: 220V/1ph/60Hz

Cold water supply: 4 l/min @ 2 bar

Software requires the user to have a PC running Windows 7 or above with a USB port.

Technical specifications

Flow rate ranges

Product stream	0-480ml/min
Washing reagent	0-480ml/min
Heating fluid	0-600ml/min
Max. temperature of heating fluid	80°C
Heat exchanger	Plate type
Feed and reagent vessel capacity	5.7 litres (each)
Heating vessel capacity	3.7 litres
Signal voltages	0-5V
Level sensor range	0-250mm
Flow sensor range	0-500ml/min
Temperature sensor range	0-100°C

(all 0-5V dc output) PCT19BR Industrial PLC Unit

Safety features

RCD in the console, all circuits protected by MCB's, 24V dc operation of solenoid valves and pump motors

Heating vessel	Thermostat limiting max temp
	Low level switch
	Vent to avoid pressurisation



Overall dimensions

Item	Process unit	Console
Length	0.550m	0.280m
Width	1.000m	0.425m
Height	0.530m	0.400m

Packed and crated shipping specifications

Volume	1.2m ³	
Gross weight	167Kg	

Ordering specifications

- ▶ A bench mounted process plant trainer with multiple streams both interacting and non-interacting. The process plant incorporates a miniature three-stage plate heat exchanger heated from a hot water circulator, two independent feed tanks, a holding tube with product divert valve and two variable-speed peristaltic pumps
- ▶ Temperature, level, flow and conductivity control loops can be implemented
- ▶ Manual control, single feedback loops, through to sophisticated cascade loops and distributed supervisory control of the whole process by a remotely located computer can be demonstrated
- ▶ The effect of 'dead time' and heat recycle can be demonstrated
- ▶ An electrical console provides measurement and control of the process plant and enables a variety of control techniques including manual operation, on/off control, control from an external signal and control from a PC or PLC
- ▶ The equipment incorporates electrical fault simulation and control, data logging software, and a USB computer interface

Optional accessories

PCT19BR: Industrial PLC Unit

PLC unit incorporating Allen Bradley SLC500 complete with proprietary ladder logic setup program (requiring user supplied PC). This program is initially configured by Armfield for two analogue input/output control loops suited to the PCT23MKII Process Plant Trainer unit, but may be reconfigured by users via their PC.

PCT20H: Industrial PID Controller

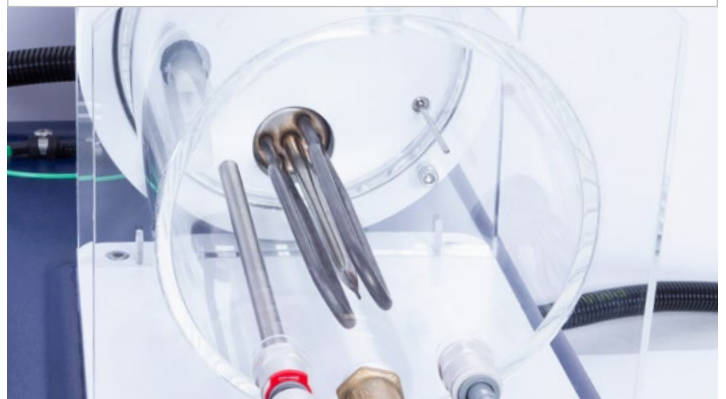
PID controller, incorporating a Honeywell UDC3200 series unit with voltage/mA input and output for single loop control and alarm configurations. A software package is supplied on disk to demonstrate the basic principles of SCADA whereby a user supplied PC can address the PID controller directly.

PCT23SCADA: SCADA Software

This software contains the facilities required to demonstrate SCADA using the Armfield PCT23MKII and PCT19BR.

It includes:

- SLC500 ladder logic routines written specifically for the PCT23MKII
- The communications facilities to enable the PCT23MKII software to display and data log the SLC500 parameters
- The additional exercises for the PCT23MKII, enabling SCADA to be demonstrated in the same manner as the other exercises



Ordering codes

PCT19BR: Industrial PLC Unit

PCT20H: Industrial PID Controller

Armfield standard warranty applies with this product

Knowledge base

- > 28 years expertise in research & development technology
- > 50 years providing engaging engineering teaching equipment

Benefit from our experience, just call or email to discuss your laboratory needs, latest project or application.

An ISO 9001:2015 Company



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