TECHNICAL TRAINING SOLUTIONS

ELECTRICAL COURSES | INSTRUMENTATION COURSES | MECHANICAL COURSES

CONTROL and INSTRUMENTATION

COURSE 500: 5 DAYS: Max 8 Candidates

This course covers the key aspects of current instrumentation and process control technology and is designed to enable maintenance personnel to carry out commissioning, calibration and maintenance of the typical devices used for measurement and control in industrial systems.

PARTICIPANTS

The course is ideal for those who presently possess some electrical knowledge, work in a maintenance environment and seek to expand their activities to include process control and instrumentation systems. This course is a combination of Course 510 and Course 515.

COURSE PRESENTATION

The course is extensively 'hands on', giving participants considerable practical experience of the devices typically found in industry. Comprehensive course notes are provided.

COURSE OBJECTIVES

On completion of the course, participants will be able to

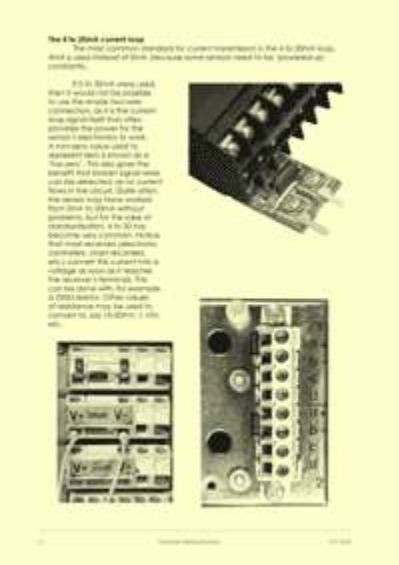
- understand the health and safety implications of working with closed-loop control systems
- identify the various methods of signal transmission
- correctly connect electrical and air-powered devices
- understand the equipment used in temperature, pressure, level and flow measurement
- understand current loops and recognise the common output devices
- correctly use a range of industrial calibration equipment
- correctly connect, commission and calibrate current loop devices, temperature transmitters, pressure switches, pressure sensors, dp cells, ultrasonic level meters, load cell amplifiers, I to P converters and HART devices
- understand the principles of turbidity, density, pH, and weight measurement
- understand the relevance of the three terms (PID) used in controllers
- identify the capabilities of controllers from their exterior markings
- configure a range of industry standard electronic controllers
- manually tune electronic controllers
- determine when a controller is correctly tuned.

Successful completion of the course leads to the award of the Technical Training Solutions Certificate of Competence 500: Control and Instrumentation.

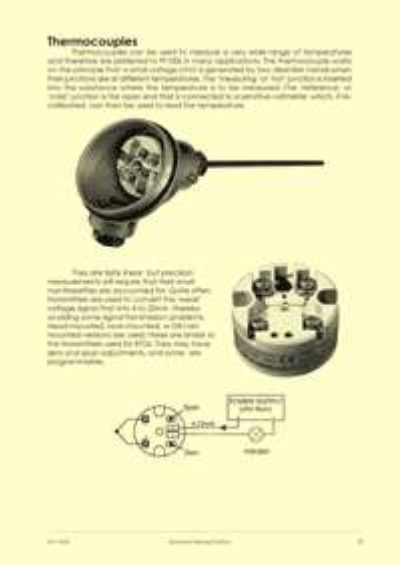
What do candidates on the Control and Instrumentation course actually do?

The control and instrumentation course involves an extensive understanding of current loops and the devices typically found on them. Candidates look in detail at the devices used to measure temperature, pressure, level and flow, and briefly at control valves, load cells, turbidity, density and pH, then go on to study the devices commonly used to control industrial processes.

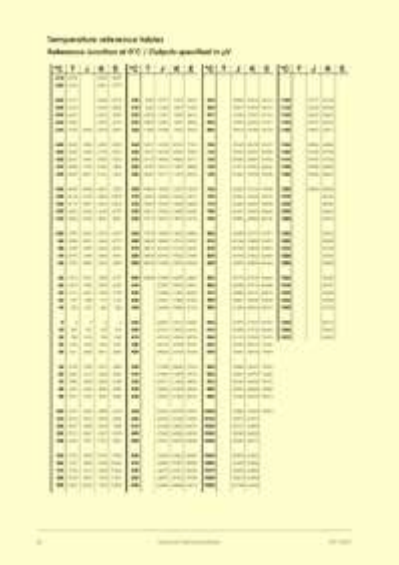
The course notes are quite extensive and explain how the various devices are used, without getting involved in the underlying theory. For example, we would look in detail at what signals a thermocouple produces, but only very briefly at how it works. Some sample pages from the course notes give an indication of this approach, the following pages describing how burden resistors are fitted to the rear panels of instruments, what industrial temperature sensors and transmitters actually look like, our own specially-designed calibration tables for thermocouples, the use of dp cells, how hydrostatic pressure measurements are converted to level measurements using pressure sensors and how manifolds are used to zero dp cells used in flow metering:



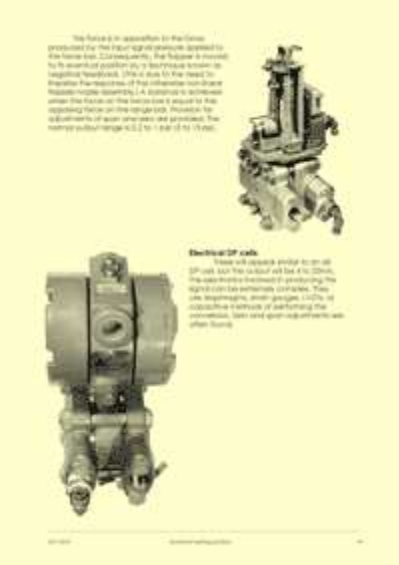
Page 10 of the control and instrumentation training course notes: Describing the burden resistors connected across current loop devices' terminals



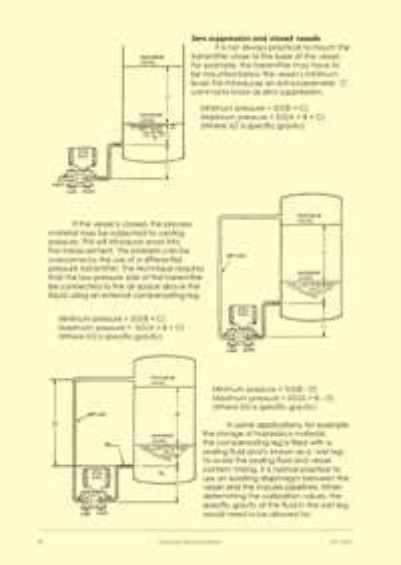
Page 29 of the control and instrumentation training course notes: Analysing the various types of industrial temperature sensors used



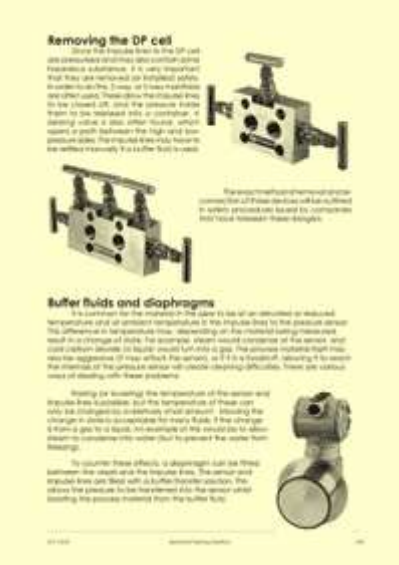
Page 32 of the control and instrumentation training course notes: Checking the voltages produced by various thermocouples



Page 47 of the control and instrumentation training course notes: Looking at various types of industrial dp cells

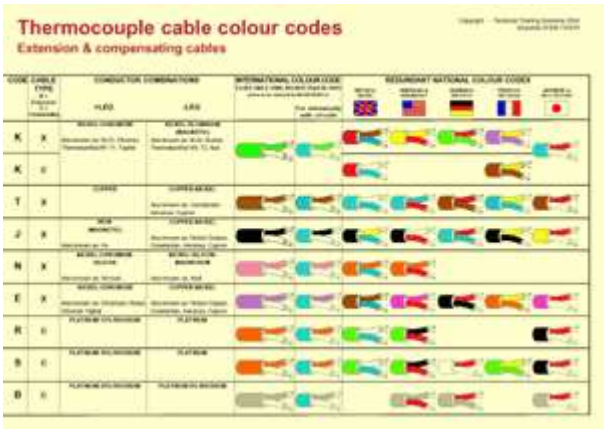


Page 57 of the control and instrumentation training course notes: Analysing the pressures produced in tanks with suppressed or elevated zeros and dry and wet legs



Page 103 of the control and instrumentation training course notes: Describing the three and five port manifolds used with dp cells and how a dp cell might be safely disconnected

Colour handouts are issued to candidates when necessary - for example when looking at the complex colour-coding systems used for thermocouple cables and connectors:



The thermocouple cable colour code reference handout issued to candidates on the control and instrumentation training course

The course involves connecting various devices into current loops so that candidates learn about how current loops work and how devices are connected into them. They also calibrate these devices using a range of professional industrial Time Electronics current calibrators, used throughout the instrumentation engineering world.

The Time Electronics current calibrators used on the control and instrumentation training course

We also connect up a range of industry-standard Beka loop indicators, looking at the various configuration options and adjusting them so that they indicate the required PV at the zero and span settings.

The Beka loop indicators used on the control and instrumentation training course

Candidates on the instrumentation and process control course then learn about the various devices used in industrial temperature measurement systems - we concentrate on thermocouples and Pt100s and their associated cabling, connectors and transmitter heads. Candidates connect up various sensors, looking at the signals that they produce and build current loops around the relevant transmitters.

The thermocouple cables, connectors, sensors and transmitter heads used on the control and instrumentation training course

The circuits built by candidates are then calibrated using industrial temperature calibration units. Candidates learn about issues like cold junction compensation and three/four wire measurements.

The thermocouple calibrators and decade resistance boxes used on the control and instrumentation training course

Candidates then learn about pressure measurement: the various units used to quantify pressure and how industrial pressure measurement devices should be calibrated, using industrial pressure sources.

The industrial pressure sources used on the control and instrumentation training course

For further practice at using the pressure sources, candidates on the instrumentation and process control course then connect and calibrate a range of industrial pressure switches.

The industrial pressure switches used on the control and instrumentation training course

Industrial pressure transmitters are then connected on to current loops and calibrated using the pressure sources.

The industrial pressure transmitters used on the control and instrumentation training course

Candidates then learn about level measurement systems and the various methods by which industrial measurements are made are analysed; we look at hydrostatic, load cell and bubbler systems. Ultrasonic measurement systems are quite common and are therefore the main focus of the instrumentation and process control course.

The ultrasonic level measurement systems used on the control and instrumentation training course

Candidates are then introduced to the more modern field-programmed 'smart' devices, which provide for remote calibration. Candidates connect, configure and calibrate a smart device using hand-held programming units, allowing them to experience how modern instrumentation is calibrated.

The HART dp cells and smart communicators used on the control and instrumentation training course

Many instrumentation systems control processes using valves and we therefore look at the various types of control valves, I to P converters and valve positioners commonly used and how these would be connected and calibrated.

One of the control valves used on the control and instrumentation training course

One of the I to P converters used on the control and instrumentation training course

Weighing machines are commonly used in industrial instrumentation systems to quantify the contents of a container and we therefore look in detail at the range of 4-wire and 6-wire load cells in common use and examples of the transmitter electronics typically connected to them.

One of the 6-wire load cells used on the control and instrumentation training course

The load cell amplifier used on the control and instrumentation training course

One of the 4-wire load cells used on the control and instrumentation training course

Various other measurements (turbidity, density, conductivity and pH) are used in some industries, and we therefore look at each of these, giving candidates the opportunity to concentrate on them if they are relevant to their workplace. A stock of calibration and buffer fluids are used to create a range of readings for each measurement.

The conductivity meter used on the control and instrumentation training course

The turbidity meter used on the control and instrumentation training course

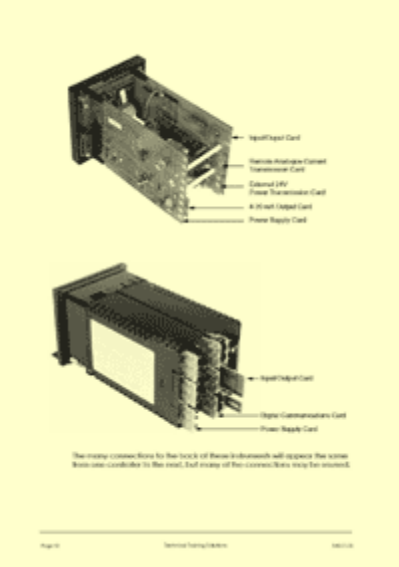
The pH meter used on the control and instrumentation training course

The instrumentation and process control course requires a clean air supply and in order to simplify the logistics of the training course we use our own (silent) compressor. All the tools needed by the candidates to make the electrical and pneumatic connections to the devices involved in the practical exercises are provided by us.

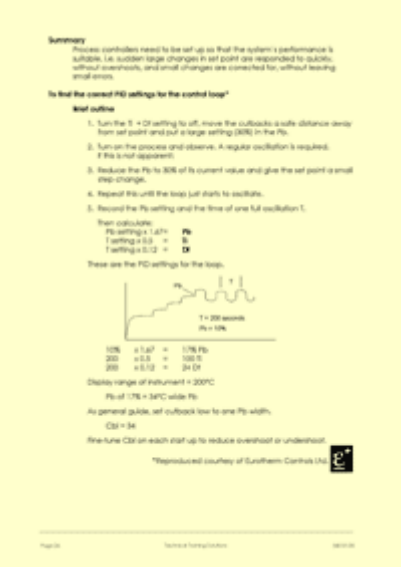
The silent compressor used on the control and instrumentation training course

The tools used on the control and instrumentation training course

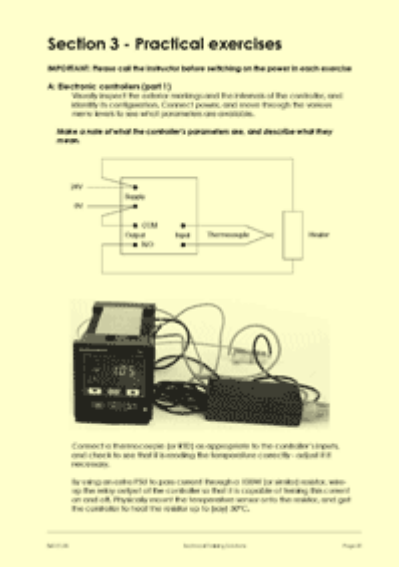
Candidates on the control and instrumentation training course learn about the theoretical aspects of open and closed-loop control systems, but *without getting involved in the complex mathematics* traditionally used to describe and analyse these systems. Our candidates are shown what the most common electronic controllers typically look like and study their markings and features (for example front panel buttons, sub-assembly cards, internal programming switches, etc). We then show candidates how the controllers should be configured, calibrated and tuned so that they give accurate readings and behave well in dynamic situations, explaining the three terms (proportional, integral and derivative) used in common industrial control systems. Candidates are provided with comprehensive course notes.



Page 110 of the course notes for the control and instrumentation training course, describing how the innards of a controller may differ depending on its manufacturer specification and the sub-cards loaded



Page 126 of the course notes for the control and instrumentation training course , which puts forward the tuning philosophy advocated by Eurotherm for their controllers



Page 131 of the course notes for the control and instrumentation training course, which introduces one of the practical exercises - this one gets the candidates to build a temperature control system using a controller with time proportioned relay outputs to develop variable output power

We begin the practical exercises in the control section by getting the candidates to power-up a controller (candidates use a range of controllers on the course) and ensure that it is reading correctly. Candidates correct configuration and calibration errors, referring to manufacturers' manuals under the guidance of our instructor. Candidates then build a simple closed-loop temperature control system, using a controller with relay outputs and thermocouple inputs. (Candidates configure the controllers for time-proportioned relay outputs so that variable power control is possible.) Once a functional system is achieved, candidates tune the loop so that the system's dynamic response is good. They are shown how auto-tuning is activated and they can then contrast and compare this with the advantages and disadvantages of manual tuning.

One of the Eurotherm controllers used on the control and instrumentation training course

One of the Eurotherm controllers used on the control and instrumentation training course

One of the West controllers used on the control and instrumentation training course

The first set of practical exercises on control loops are based on temperature control. The rigs used have a heater, the temperature of which is measured by a Pt100 connected to the controller's input. By using time proportioned relay outputs the controller is able to bring the heater to various target temperatures.

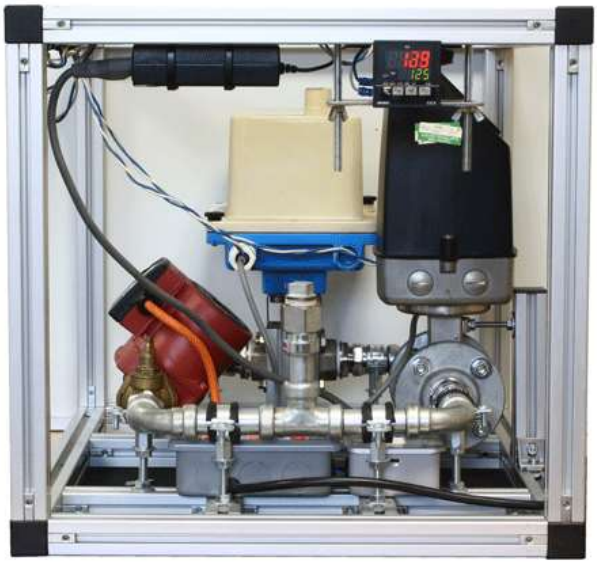
The candidates expose this system to various step changes and we can then apply what they've learned theoretically to the practical business of making sure that step transitions are critically damped by tuning the three term parameters to suit the system's dynamics.

The next set of practical exercises are based on flow control loops. We connect controllers with 4 to 20mA inputs and outputs to our specially-designed flow rigs, configuring and calibrating them as necessary. Candidates then tune these systems so that their dynamic behaviour is good. We use a range of flow rigs (each designed to require different tuning parameters) to demonstrate the alternative methods of system control used in industrial systems; electronic variable-speed drives, electrical control valves and air control valves.

One of the flow rigs used on the control and instrumentation training course: This one uses an air powered control valve

One of the flow rigs used on the control and instrumentation training course: This one uses an inverter drive controlling a variable speed electrical pump

One of the flow rigs used on the control and instrumentation training course: This one uses an electrical control valve



One of the flow rigs used on the control and instrumentation training course: This one uses an inverter drive controlling a variable speed electrical pump

The above exercises generate all the evidence we need to be confident that they have achieved the skills-based course objectives relating to closed loop control systems. We conclude with a short multiple choice assessment paper to ensure that they have understood the knowledge based objectives of this part of the course.

If you would like to see some of the equipment used on the control and instrumentation course for yourself, then please call us to arrange a visit to our offices in Kent. Alternatively, we can visit you anywhere in the British Isles.

CONTACT US

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