

Unit 24: Industrial Process Measurement

Unit code:	Y/600/0275
QCF Level 3:	BTEC Nationals
Credit value:	10
Guided learning hours:	60

● Aim and purpose

This unit will introduce learners to the principles involved in the operation, selection and calibration of transducers and signal processors used to measure a range of common industrial process variables.

● Unit introduction

This unit will introduce learners to the principles involved in the operation, selection and calibration of transducers and signal processors used to measure a range of common industrial process variables. The methods of system and device construction and their specifications are investigated along with relevant calibration and documentation processes.

Learners will consider the performance, operation and application of industrial transducer systems and the relationship between the physical principles of a transducer to its selection and application. Often there are requirements for signal processing once a transducer has been selected to ensure that the measurement system output meets specification. This unit provides a thorough background in the operation of signal processors and details the current systems that are available.

In many industrial process plants the process being measured can be some distance from the display systems, for example in a control room. Therefore signal transmission is required over distance. This unit identifies the variety of transmission systems and standards that are used within industrial plant.

The unit relates to the requirements and techniques of system calibration. Learners will be able to use industrial procedures and standards in order to correctly calibrate such measurement systems.

● Learning outcomes

On completion of this unit a learner should:

- 1 Know about industrial transducer systems and their applications
- 2 Know about the operation and application of signal processing systems
- 3 Be able to examine a range of signal transmission and recording systems
- 4 Be able to select and use a range of equipment to test and calibrate instruments on process plant.

Unit content

1 Know about industrial transducer systems and their applications

System performance: accuracy; error; linearity; reliability; sensitivity; resolution; range; static and dynamic characteristics eg dead time, time constant, hysteresis, steady state

Transducer types and operation: pressure eg diaphragm capsule, bellows, Bourdon tube, piezo-electric, manometers; level eg pressure gauges, DP cell transmitters, purged dip pipes, capacitive probes, ultrasonic, nucleonic, load cells, level switches; temperature eg thermocouples, metallic resistance thermometers, thermistors; flow eg Venturi, orifice plate, Pitot static tube, DP cell, conventional/smart electronic and pneumatic types, variable area, vortex, ultrasonic; nucleonic analysers eg alpha, beta, gamma, neutron; speed eg tachogenerator, radar; position eg linear/rotary potentiometer, absolute/incremental digital encoder, Linear Variable Differential Transducer (LVDT), resolver

Applications: selection of appropriate transducer in terms of process variable, system performance, environment and constraints

2 Know about the operation and application of signal processing systems

Signal converters: resistance to voltage eg potential divider, Wheatstone bridge; voltage to current; pressure to current; current to pressure; analogue to digital eg counter type, integrator type

Signal conditioners: signal standards eg 4-20mA, 1-5V, 3-15 psi, 20-100Kpa; amplification eg simple op-amp arrangements, difference amplifier; attenuation; lineariser eg square root extractor; filters eg low pass, high pass

Applications: selection of appropriate signal processing system to meet system specification in terms of signal input and signal output

3 Be able to examine a range of signal transmission and recording systems

Transmission requirements: systems eg pressure transmission, analogue electrical transmission, digital transmission; electrical standards eg RS232, RS422; transmission devices eg multiplexers; selection of appropriate medium for transmission

Recording and display devices: analogue meters eg voltmeter, ammeter, pressure gauge; trend indicators eg hand held oscilloscope, chart recorder; computer system eg Supervisory Control and Data Acquisition (SCADA), Distributed Control Systems (DCS); specifications eg acquisition time, update speeds, resolution

4 Be able to select and use a range of equipment to test and calibrate instruments on process plant

Selection and use of equipment: instrumentation specifications to determine the system inputs and outputs (range, zero requirements, span); test and calibration equipment eg multi-meters, oscilloscope, data acquisition system

Test and calibrate: calibration of process transmitters eg pressure, level, temperature, flow, nucleonic, position, speed; calibration parameters (component specification, system requirements); recording and presentation of test and calibration results; calibration process eg standards, accuracy, methods, documentation

Systems: process measurement eg vessel level, vessel pressure, air-flow supply in a bubbler system, furnace temperature

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P1 define the terms relating to system performance	M1 justify the choice of transducer to meet a given specification	D1 evaluate the performance of an industrial transmission and recording system
P2 describe a transducer type and its operation for each of pressure, level, temperature, flow, nucleonic, speed and position process variables	M2 design a signal processing system to meet a given specification	D2 document calibration results and evaluate the overall error in the measuring systems based on the individual accuracies of each element in the system.
P3 select a transducer to meet a given application [IE4]	M3 justify the choice of standard equipment for the calibration of given measuring systems.	
P4 describe the operation and application of five different types of signal converter used in process measurement		
P5 describe the operation and application of two common signal conditioning systems that can be found within process measurement		
P6 explain the signal transmission requirements for two different types of transducers		
P7 select two common recording and display devices that will meet given specifications		
P8 select the equipment required to test and calibrate a given process measurement system [IE1, IE4]		

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P9 test and calibrate a given process plant instrumentation system [SM3].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers	RL – reflective learners TW – team workers	SM – self-managers EP – effective participators
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Essential guidance for tutors

Delivery

This unit may be delivered as a stand-alone package or integrated with other units within the qualification. Wherever possible, a practical approach should be adopted in which the underpinning knowledge is consolidated using a structured programme of laboratory and workshop practical investigations and demonstrations. It is expected that learners will have access to industrial standard calibration and process equipment. Whilst lectures and case study material can provide the underpinning background knowledge, they should be used to support the practical activities and not replace hands-on experience.

Learners could work on suitably constructed rigs which model real systems or be encouraged to produce suitable evidence from their workplace.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment

Whole-class teaching:

- introduction to unit, scheme of work and methods of assessment
- explain the performance of transducer systems and the different static and dynamic characteristics
- describe the different types of transducers and their operation including pressure, level, temperature, flow, nucleonic, speed and position. Discuss typical applications of industrial transducer systems.

Case study and/or industrial visit:

- research industrial applications of transducer systems.

Practical workshop activities:

- practical investigation of different types of transducer.

Prepare for and carry out **Assignment 1: Industrial Transducer Applications** (P1, P2, P3, M1, D1).

Whole-class teaching:

- explain the operation of signal converters and the different conversion processes
- explain signal conditioners including signal standards, amplification, attenuation and lineariser.

Case study:

- research industrial applications of signal processing systems.

Topic and suggested assignments/activities and/assessment

Whole-class teaching:

- describe the operation of transmission systems and the use of electrical standards. describe the use of transmission devices. Explain the selection of appropriate medium for transmission
- explain the operation and use of recording and display devices including analogue meters, trend indicators and computer systems. Explain the use of specifications.

Practical workshop activities:

- investigate and examine a range of signal transmission and recording systems.

Prepare for and carry out **Assignment 2: Signal Processing, Transmission and Recording Systems** (P4, P5, P6, P7, M2).

Whole-class teaching/practical demonstration:

- explain and demonstrate the selection and use of test and calibration equipment on process plant.

Practical workshop activities:

- working with a process measurement system determine system inputs and outputs and select and use suitable equipment to test and calibrate instruments.

Prepare for and carry out **Assignment 3: Testing and Calibrating Process Plant Instrumentation** (P8, P9, M3, D2).

Feedback, unit evaluation and close.

Assessment

Assessment evidence for the first three pass criteria (P1-P3) could be produced through a written report. After defining relative terms (P1) learners will need to consider seven process variables (pressure, flow, level, temperature, nucleonic, speed and position) and describe the performance and operation of a transducer for each variable (P2). Learners could then be asked to select an additional transducer that will meet the needs of a given application (P3).

Evidence for pass criteria P4-P7 could be produced through an assignment that asks learners to describe the signal conversions required to enable five different transducers to provide specific signal output types. These will include voltage, current (from both voltage input and pressure input), pressure and digital (P4). Two of these systems can require the signal outputs to be conditioned to a predefined state. Typical specifications are ranged in the unit content.

In each case learners could be asked to identify and describe the operation of the signal conditioning system (P5). The range of transducers that could be used for pass criterion P6 is ranged under learning outcome 1. For each system learners could select an appropriate display or recording device that will give a specific record and display output (P7).

For pass criteria P8 and P9 assessment evidence could be produced through a practical activity in which learners calibrate a given process measurement system. Learners could produce a report on the practical activity that includes details of their selection of calibration and test equipment and describes the physical calibration procedure that was used. Observation records or witness statements could be used to provide additional process evidence.

Assessment evidence for M1 could come from an extension of the assessment report covering pass criteria P1, P2 and P3. An additional task could ask learners to justify their choice of the transducer selected for P1.

Assessment of M2 could be achieved through an extension to the assignment covering criteria P4-P7. Learners could be asked to design a signal processing system to meet a given specification. This may be in the form of a block, signal or circuit diagram.

For M3, evidence could be collected during the practical activity and report covering criteria P8-P9. A written task or oral questioning could be used to ask learners to justify their selection of equipment when undertaking the calibration of a given process measurement system.

Assessment of D1 could be achieved through an extension of the assignment covering criteria P1, P2, P3 and M1. Having selected and explained the choice of a signal processing system, learners could be asked to include a given transmission system to transmit the measured variable to a given recording device. Learners could then be asked to evaluate the performance of the transmission and recording device through a practical activity. This evaluation can be presented as a short evaluative report.

For D2, assessment evidence could build upon that gathered as part of the practical task covering criteria P8, P9 and M3. Having calibrated a given process measurement system, learners could be asked to fully document the calibration process using industrial documentation standards. Within this documentation learners could evaluate the calibration data and determine the overall system error performance relative to known system parameters.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, M1, D1	Industrial Transducer Applications	Learners have been asked to produce a report on industrial transducers, identifying a transducer for a particular application.	A written assignment with a series of tasks requiring descriptions of transducers and their applications.
P4, P5, P6, P7, M2	Signal Processing, Transmission and Recording Systems	Learners have been asked to produce an information poster for new apprentices detailing signal processing and signal transmission and recording systems.	A written assignment with a series of tasks requiring descriptions/explanations of signal processing systems and signal transmission and recording systems.
P8, P9, M3, D2	Testing and Calibrating Process Plant Instrumentation	Learners need to carry out testing and calibration on an item of process plant.	A practical assignment supported by a report of each learner's activities, photos and observation records.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
		Principles and Applications of Engineering Measurement Systems
		Industrial Plant and Process Control

The unit will contribute skills, knowledge and understanding towards the evidence requirements of several units within the Level 3 NVQ in Engineering Maintenance, particularly:

- Unit 40: Maintaining Instrumentation and Control Systems
- Unit 42: Maintaining Environmental Control Equipment.

The unit also supports the following unit in the Level 3 NVQ in Installation and Commissioning:

- Unit 24: Commissioning Instrumentation and Control Equipment and Systems.

Essential resources

Industrial process measurement, calibration and test equipment is essential for this unit. Learners should have access to a relevant workshop or laboratory facilities including:

- industrial plant, rigs or system simulators
- signal processing hardware or simulation software
- signal transmission hardware
- data books and manufacturers' specifications
- paper-based or IT-based data logging systems
- appropriate tools.

Employer engagement and vocational contexts

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI, University of Warwick) – www.warwick.ac.uk/wie/cei
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Anderson A – *Instrumentation for Process Measurement* (CRC Press, 1998) ISBN 0849398711

Fraser R – *Process Measurement and Control* (Pearson Higher Education, 2000) ISBN 0130222119

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	analysing and evaluating information relating to transducers and their applications, judging its relevance and value identifying questions to answer and problems to resolve when selecting suitable testing and calibration equipment for a process measurement system
Self-managers	organising time and resources and prioritising actions when carrying out testing and calibration activities.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Reflective learners	setting goals and success criteria for their development and work reviewing progress and acting on the outcomes
Team workers	collaborating with others when working in small groups on practical activities.

● Functional Skills – Level 2

Skill	When learners are ...
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	<p>describing transducer types and their operation</p> <p>describing the operation and application of different types of signal converter used in process measurement</p> <p>describing the operation and application of signal conditioning systems that can be found within process measurement</p>
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating transducer types, signal conditioning systems and their operation
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	<p>describing transducer types and their operation</p> <p>describing the operation and application of different types of signal converter used in process measurement</p> <p>describing the operation and application of signal conditioning systems that can be found within process measurement.</p>