Next Generation Higher National Unit Specification

Instrumentation and Control: Measurement Systems (SCQF level 7)

Unit code: J6D0 47

SCQF level: 7 (24 SCQF credit points)

Valid from: session 2024–25

Prototype unit specification for use in pilot delivery only (version 2.0) October 2024

This unit specification provides detailed information about the unit to ensure consistent and transparent assessment year on year.

This unit specification is for teachers and lecturers and contains all the mandatory information required to deliver and assess the unit.

This edition: October2024 (version 2.0)

Unit purpose

This unit is for learners who want to develop their core instrumentation and control skills and knowledge.

They learn about a variety of topics, including:

- pressure, level, temperature, and flow measurement
- analysers and detectors
- industrial actuators
- PID controllers
- complex control systems

Entry to this unit is at your centre's discretion. However, we recommend that learners have a broad knowledge and understanding of electrical, electronic, mechanical, and mathematical concepts and principles. For example, learners may have an SCQF level 6 qualification in an engineering discipline such as measurement and control, electrical, electronics, mechanical or engineering systems. Learners with relevant, equivalent workplace experience or SCQF level 6 qualifications, for example Higher Physics, may also study this unit.

On completing this unit, learners can progress to further study or employment in a wide range of engineering industries such as: oil and gas, process, utilities, renewables, and food and beverage.

Unit outcomes

Learners who complete this unit can:

1 demonstrate knowledge and understanding of pressure measurement systems
2 demonstrate knowledge and understanding of level measurement systems
3 demonstrate knowledge and understanding of temperature measurement systems
4 demonstrate knowledge and understanding of flow measurement systems
5 demonstrate knowledge and understanding of process analysers and fire and gas detectors
6 demonstrate knowledge and understanding of industrial actuators
7 demonstrate knowledge and understanding of complex control systems

Evidence requirements

All outcomes can be assessed holistically using product, written and/or oral recorded evidence. Learners generate evidence under controlled or supervised, open-book conditions, and it must be authenticated as being all their own work. The evidence must contain a mix of knowledge and skills items that matches the evidence requirements of the unit, and include various forms of evidence, such as:

- assignments
- case studies
- reports
- essays
- simulations
- structured controlled tests
- practical evidence
- other relevant sources of evidence

Outcome 1

- Demonstrate knowledge and understanding of the principle of operation of a range of pressure measurement systems.
- Solve mathematical problems associated with pressure measurement systems.

Outcome 2

- Demonstrate knowledge and understanding of the principle of operation of a range of level measurement systems.
- Solve mathematical problems associated with level measurement systems.

Outcome 3

- Demonstrate knowledge and understanding of the principle of operation of a range of temperature measurement systems.

- Solve mathematical problems associated with temperature measurement systems.

Outcome 4

- Demonstrate knowledge and understanding of the principle of operation of a range of flow measurement systems.
- Solve mathematical problems associated with flow measurement systems.

Outcome 5

- Demonstrate knowledge and understanding of the operation and applications of different types of process analysers.
- Demonstrate knowledge and understanding of the operation and applications of different types of fire and gas detectors.

Outcome 6

- Demonstrate knowledge and understanding of the construction and operation of actuators.
- Analyse the construction and operation, fail safe criteria, and flow/lift characteristics of control valves.

Outcome 7

- Generate pipe and instrumentation diagrams to relevant British Standards.
- Demonstrate knowledge and understanding of the PID control parameters including gain, integral action time (IAT) and derivative action time (DAT).
- Demonstrate knowledge and understanding of the operation of complex control systems and industrial applications.

Knowledge and skills

The following table shows the knowledge and skills covered by the unit outcomes:

Knowledge	Skills
Learners should understand: ♦ the principle of operation of pressure, level, temperature, and flow measurement systems ♦ operation and applications of process analysers ♦ operation and applications of fire and gas detectors ♦ construction and operation of actuators ♦ PID control parameters including gain, IAT and DAT ♦ operation of complex control systems and industrial application	Learners can: ♦ solve mathematical problems associated with pressure, level, temperature, and flow measurement systems ♦ analyse the construction, operation and characteristics of control valves ♦ generate and analyse pipe and instrumentation diagrams

Meta-skills

Throughout the unit, learners develop meta-skills to enhance their employability in the engineering sector.

Self-management

Learners develop their integrity skills (self-awareness, ethics and self-control) and adapting skills (critical reflection and self-learning) through working on their portfolio or investigation reports. They also develop their initiative skills (decision making, self-motivation and responsibility) when conducting their learning and producing reports.

Social intelligence

Learners develop their communication skills (receiving information, listening and giving information) when accessing the unit material through a virtual learning environment, keeping an e-portfolio and writing technical reports. They also develop their collaborating skills (team working and collaboration) when engaging with fellow learners, teacher or lecturer.

Innovation

Learners develop their curiosity (information sourcing, questioning and observation), sense-making (holistic thinking and analysis) and critical thinking skills (deconstruction, logical thinking and judgement) when conducting their learning activities and working on their projects either individually or in groups.

Literacies

Learners develop core skills in the following literacies:

Numeracy

Learners develop their numeracy skills when performing calculations related to the measurement systems and PID controllers.

Communication

Learners develop their communication skills when studying the course material and engaging with fellow learners, teacher or lecturer.

Digital

Learners develop digital literacy by accessing the course material through a virtual learning environment, if available.

Delivery of unit

This unit is part of the Higher National Certificate (HNC) in Engineering. The framework includes mandatory and optional units, and you can tailor the combination of units to specific engineering pathway needs.

While the exact time allocated to this unit is at your centre’s discretion, the notional design length is 120 hours.

The amount of time you allocate to each outcome is at your discretion, however we suggest you spend approximately 17 hours on each outcome, including assessment.

Additional guidance

The guidance in this section is not mandatory.

Content and context

This unit has been developed to give learners some of the knowledge and skills they need to support a career in instrumentation and control engineering.

Demonstrate knowledge and understanding of pressure measurement systems (outcome 1)

Introduces learners to pressure measurement systems. This provides them with the key principles that relate to measuring pressure in an industrial situation. You should include a range of electronic pressure transducers, such as:

- strain gauge
- capacitance
- resonant wire
- piezoelectric
- magnetic
- optical

You should also teach them about physical relationships that relate to pressure measurement, such as:

- pressure
- stress
- mechanical strain
- electrical strain
- Hooke’s law
- Young’s modulus of elasticity

Demonstrate knowledge and understanding of level measurement systems (outcome 2)

Introduces learners to level measurement systems. This provides them with the key principles that relate to measuring level in an industrial situation. You should include a range of electronic level transducers, such as:

- hydrostatic head using a DP cell
- displacer
- capacitance
- ultrasonic
- radar
- optical

You should also teach them about physical relationships that relate to level measurement, such as:

- Archimedes principle
- law of floatation
- hydrostatic head pressure

Demonstrate knowledge and understanding of temperature measurement systems (outcome 3)

Introduces learners to temperature measurement systems. This provides them with the key principles that relate to measuring temperature in an industrial situation. You should include a range of electronic temperature transducers, such as:

- filled system thermometers
- resistance thermometers
- thermocouples
- thermistors
- radiation pyrometers

You should also teach them about physical relationships that relate to temperature measurement, such as:

- gas laws — pressure law, Charles's law and Boyle's law
- resistance versus temperature relationship
- Stefan–Boltzmann equation
- Seebeck effect

Demonstrate knowledge and understanding of flow measurement systems (outcome 4)

Introduces learners to flow measurement systems. This provides them with the key principles that relate to measuring flow in an industrial situation. You should include a range of electronic flow transducers, such as:

- differential pressure (typically orifice plate)
- electromagnetic flowmeter
- turbine meter
- pitot tube
- ultrasonic transit time flowmeter
- Doppler flowmeter
- vortex flowmeter
- Coriolis flowmeter
- thermal mass flowmeter

You should also teach them physical relationships that relate to flow measurement, such as:

- continuity equation
- laminar and turbulent flow
- Reynolds number
- Bernoulli's principle
- coefficient of discharge

Demonstrate knowledge and understanding of process analysers and fire and gas detectors (outcome 5)

Introduces learners to process analysers and fire and gas detectors. This provides them with a good understanding of the operating principles of the analysers and detectors. You should include a range of industrial analysers, such as:

- pH
- conductivity
- oxygen
- chromatography

You should also include a range of industrial detectors, such as:

- smoke
- flame
- heat
- infrared
- ultraviolet

Demonstrate knowledge and understanding of industrial actuators (outcome 6)

Introduces learners to actuators used in industry. This provides them with a good understanding of the relevance of actuators in control systems. You should include the construction and operation of a range of devices used in industry, such as:

- solenoid valves
- pistons
- pumps

You should also teach learners construction and operation, fail safe criteria and flow/lift characteristics.

Demonstrate knowledge and understanding of complex control systems (outcome 7)

Introduces learners to PID controllers and their use in industrial control systems. This provides them with a firm understanding of the long-established concept of PID control. Learners gain understanding of the theory of proportional, integral and derivative control. In addition, they learn about the effects of the control parameters on the response of a measurement system.

You should introduce learners to complex control systems. This provides them with a firm understanding of the use of control systems in industrial applications. Teach them how to generate pipe and instrumentation diagrams; and the operation of complex control systems, such as:

- cascade control
- ratio control
- feedforward control
- multivariable control

You should also teach learners about where complex control systems can be applied, such as:

- distillation columns
- boilers
- compressors

This unit does not require any specific resources other than ICT. However, understanding of subject material is enhanced if a range of instrumentation and control systems are available for demonstration purposes.

Approaches to delivery

We suggest you deliver outcome 7 last, as it builds on knowledge from earlier outcomes. You can deliver outcomes 1 to 6 in any order.

Do this in a learning space or virtual learning environment. You should teach primarily using problem-based-learning (PBL) techniques, such as case studies and mini projects, supported by other methods. The holistic teaching format of PBL encourages learners to consider the deeper context of the theory.

Approaches to assessment

We recommend that you assess this unit holistically. This consists of review of case study reports and mini projects. Learners should generate evidence (for example, a coursework report) under controlled or supervised, open-book conditions, and collate all evidence in their individual portfolios.

Learners should demonstrate evidence of all knowledge and skills in the context of one or more overarching instrumentation and control engineering scenarios.

For case studies and mini projects, you can assess knowledge and skills using coursework exercises.

Learners can keep a linear reflective account to measure their meta-skills, digital literacy, professional skills and wider employer-desired skills. They should record this in their portfolio. You should provide learners with support, guidance and feedback on areas of development, and signpost developmental opportunities.

In addition, you can use observation, anecdotal comments and a checklist as evidence. These are valid ways of gathering evidence of learning. The actual amount of evidence is not critical, it is the quality that is important. Learners should demonstrate evidence of all knowledge and skills in the context of one or more overarching instrumentation and control engineering scenarios.

You must give learners access to online facilities, reference materials, appropriate software packages and other appropriate support materials.

As the assessment is under controlled or supervised, open-book conditions, you must take care to ensure authenticity. You can do this by using variable values in the coursework, making use of oral questioning and using originality-checking software.

Equality and inclusion

This unit is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

You should take into account the needs of individual learners when planning learning experiences, selecting assessment methods or considering alternative evidence.

Guidance on assessment arrangements for disabled learners and/or those with additional support needs is available on the assessment arrangements web page: www.sqa.org.uk/assessmentarrangements.

Information for learners

Instrumentation and Control: Measurement Systems (SCQF level 7)

This information explains:

- what the unit is about
- what you should know or be able to do before you start
- what you need to do during the unit
- opportunities for further learning and employment

Unit information

This unit provides you with knowledge and skills specific to instrumentation and control engineering. It is aimed at those who want to become instrumentation and control engineering technicians.

Before starting this unit, we recommend that you have a broad knowledge and understanding of electrical, electronic, mechanical and mathematical concepts and principles. This could be an SCQF level 6 qualification in an engineering discipline, such as measurement and control, electrical, electronics, mechanical or engineering systems. If you have relevant, equivalent workplace experience or SCQF level 6 qualifications, for example Higher Physics, you can also study this unit.

You learn about topics such as pressure, level, temperature and flow measurement systems, analysers and detectors, PID control, industrial actuators, and complex control systems.

- Outcome 1 introduces you to pressure measurement systems. This provides you with the key principles that relate to measuring pressure in an industrial situation. This includes learning about the operation of the main types of pressure measuring devices currently used in industry.

- Outcome 2 introduces you to level measurement systems. This provides you with the key principles that relate to measuring level in an industrial situation. This includes learning about the operation of the main types of level measuring devices currently used in industry.

- Outcome 3 introduces you to temperature measurement systems. This provides you with the key principles that relate to measuring pressure in an industrial situation. This includes learning about the operation of the main types of temperature measuring devices currently used in industry.

- Outcome 4 introduces you to flow measurement systems. This provides you with the key principles that relate to measuring flow in an industrial situation. This includes learning about the operation of the main types of flow measuring devices currently used in industry.

- Outcome 5 introduces you to process analysers and fire and gas detectors. This provides you with a good understanding of the operating principles of the analysers and detectors. This includes learning about the operation of process analysers and gas detectors currently used in industry.

- Outcome 6 introduces you to actuators used in industry. This provides you with a good understanding of the operation and characteristics of actuators in control systems.

- Outcome 7 introduces you to PID controllers and their use in industrial control systems. This provides you with a firm understanding of the long-established concept of PID control. It also introduces you to complex control systems. This provides you with a firm understanding of the use of control systems in industrial applications and it reinforces your understanding of instrumentation and control systems. In addition, you learn how to generate pipe and instrumentation diagrams (P&IDs).

There is a holistic approach to assessment, where you demonstrate evidence of all knowledge and skills in the context of one or more overarching instrumentation and control engineering scenarios.

You are assessed using a variety of ways, including review of case study reports and mini projects. You should collate all evidence in your individual portfolio.

On completion of this unit, you can demonstrate knowledge and understanding of:

- pressure measurement systems
- level measurement systems
- temperature measurement systems
- flow measurement systems
- process analysers and fire and gas detectors
- industrial actuators
- complex control systems

This unit provides you with suitable knowledge and skills to progress to further study or employment in a wide range of engineering industries such as: oil and gas, process, utilities, renewables, and food and beverage.

Meta-skills

Throughout the unit, you can develop a wide range of personal skills to enhance your employability in the engineering sector. These skills include self-management, social intelligence and innovation.

Self-management

You develop the skills of focusing, adapting and using your initiative as you study the course material.

Social intelligence

You develop your communication skills as you receive information from your teacher or lecturer.

Innovation

You develop curiosity, sense-making and critical thinking skills when studying the operation of instrumentation and control systems.

Administrative information

Published: October 2024 (version 2.0)

Superclass: VE

History of changes

Version	Description of change	Date
2.0	♦ 'Evidence requirements' updated to clarify conditions of assessment. ♦ 'Approaches to assessment' updated.	October 2024

Note: please check SQA's website to ensure you are using the most up-to-date version of this document.