

SQA Advanced Unit Specification

General information for centres

Unit title: Industrial Systems

Unit code: HT79 48

Unit purpose: This Unit has been designed to enable candidates to develop knowledge and understanding of a variety of Industrial Systems.

On completion of the Unit the candidate should be able to:

- 1 Analyse a variety of industrial systems.
- 2 Describe the principle of operation of measurement devices used in industrial systems.
- 3 Identify the control techniques used in industrial systems and explain the operation of control algorithms, software and hardware used to achieve system control.
- 4 Describe the concepts and methods involved in condition monitoring of industrial systems.

Credit points and level: 1 SQA Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates.*

Recommended prior knowledge and skills: It would be an advantage for candidates to have a basic knowledge and understanding of engineering systems. This may be evidenced by the possession of SQA Advanced Units: Thermofluids, Statics and Strength of Materials, Dynamics, Plants Systems, Single Phase AC Circuits, Digital Electronics, Analogue Electronics: An Introduction, Engineering Measurement and NQ Units: Thermofluids, Dynamics, Pneumatics and Hydraulics and Machines and Mechanisms.

Core Skills: There may be opportunities to gather evidence towards the following listed Core Skill components in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Written Communication	SCQF level 6
Use of Numbers	SCQF level 6
Oral Communication	SCQF level 6
Critical Thinking	SCQF level 6
Reviewing and Evaluating	SCQF level 6
Working with Others	SCQF level 6

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Context for delivery: If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

Assessment: This Unit lends itself to holistic assessment. The assessment for all the Outcomes in this Unit should be combined together into one assessment paper. This paper should be taken by candidates at a single assessment event that should last no more than two hours. Assessment should be conducted under controlled, supervised conditions.

SQA Advanced Unit specification: statement of standards

Unit title: Industrial Systems

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The sections of the Unit stating the Outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Analyse a variety of industrial systems

Knowledge and/or skills

- ◆ Mechanical and machine systems
- ◆ Electrical interaction:
 - Standardised signals (I/P, P/I, I/E,E/I)
 - Solenoids and directional control valves
 - Electrical safety (guarding)
 - IP rating
 - Applications
- ◆ Pneumatic systems and operation:
 - Working principles
 - Simple circuits
 - Advantages and disadvantages
 - Applications
- ◆ Vacuum machine systems:
 - Vacuum pumps
 - Circuitry
 - Applications
- ◆ Block diagrams of industrial systems
- ◆ Industrial machine development
- ◆ Industrial Safety

Evidence Requirements

Evidence for the knowledge and/or skills items in this Outcome should be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that they can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **four out of seven** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of four out of seven knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all four items.

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Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ describe, with the aid of a diagram, the function of one mechanical handling or industrial automated machine system
- ◆ describe two aspects of electrical interaction with industrial systems
- ◆ state one industrial application of a vacuum system and draw a circuit diagram for that application
- ◆ state one industrial application of a pneumatic system and explain the operation of a system from a given circuit diagram
- ◆ construct a block diagram to show the unit elements of a given industrial system
- ◆ briefly describe the need for ongoing industrial machine development
- ◆ state one current industrial standard or procedure to meet the specification of a given industrial system

The assessment of this Outcome must be combined with that for Outcomes 2, 3 and 4 to form a single assessment paper, details of which are given under the Evidence Requirements for Outcome 4.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

Outcome 2

Describe the principle of operation of measurement devices used in industrial systems

Knowledge and/or skills

- ◆ Systems parameters for industrial systems
- ◆ Operation and uses of sensors
- ◆ Operation and uses of actuators
- ◆ A/D and D/A conversion and signal conditioning
- ◆ Industrial system controllers:
 - Micro-controller
 - PLC
 - Computer control
 - SCADA
 - Distributed Control System

Evidence Requirements

Evidence for the knowledge and or skills items in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that they can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **three out of five** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of three out of five knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

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Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ select suitable sensors and actuators to meet the requirements of the system parameters of an industrial system, from a list of available sensors and actuators (two sensors and two actuators)
- ◆ explain the operation of one sensor/transducer and give one application for the sensor/transducer
- ◆ explain the operation of one actuator and give one application of the actuator
- ◆ select a suitable A/D or D/A converter for a sensor or actuator in an industrial system
- ◆ briefly describe, with the aid of a block diagram, the stages of A/D or D/A conversion and signal conditioning (eg. square root, linear, negative temperature coefficient)
- ◆ select a suitable controller for an industrial system and justify the selection of that controller for the given industrial system operation

The assessment of this Outcome should be combined with that for Outcomes 1, 3 and 4 to form a single assessment paper, details of which are given in the Evidence Requirements for Outcome 4.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

Outcome 3

Identify the control techniques used in industrial systems and explain the operation of control algorithms, software and hardware used to achieve system control.

Knowledge and/or skills

- ◆ Control terminology:
 - Resolution
 - Accuracy
 - Hysteresis
 - Linearity
 - Drift
 - Dead zone
 - Saturation
- ◆ Open and closed loop system responses
- ◆ Control techniques:
 - Sequential control (event and timed functions)
 - Two step control
 - Proportional, Integral and Derivative (PID) control algorithm
 - Critically tuned systems
 - Digital systems
 - Fuzzy logic
 - Neural networks
- ◆ Mimic diagrams and process flow diagrams
- ◆ Design of industrial system control including software and hardware

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Evidence Requirements

Evidence for the knowledge and or skills items in this Outcome should be provided on a sample basis. The evidence may be presented in response to specific questions.

Each candidate will need to demonstrate that they can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **three out of five** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of three out of five knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ explain the meaning of two control terms
- ◆ sketch a typical open loop and closed loop control output response
- ◆ describe how the PID algorithm functions to control a system and describe how one of the other control techniques listed functions
- ◆ with the aid of a diagram describe the interaction of software and hardware within an industrial system
- ◆ explain the use and advantages of mimic diagrams and process flow diagrams

The assessment of this Outcome must be combined with that for Outcomes 1, 2 and 4 to form a single assessment paper, details of which are given in the Evidence Requirements for Outcome 4.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

Outcome 4

Describe the concepts and methods involved in condition monitoring of industrial systems

Knowledge and/or skills

- ◆ Industrial machine health
- ◆ Fault diagnostic methods
- ◆ Industrial machine maintenance
- ◆ Industrial systems maintenance recording
- ◆ Data logging systems and applications
- ◆ Systems monitoring techniques:
 - Vibration analysis
 - Heat emission analysis and distinguish temperature measurement techniques
 - Noise level measurement
 - Magnetic plug inspection
 - Ferrograph precipitation
 - X-ray spectrometry
 - Gas chromatography

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Evidence Requirements

Evidence for the knowledge and or skills items in this Outcome should be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that they can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **four out of six** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of four out of six knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all four items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ state, with the aid of a sketch, the principles of machine health monitoring and give one example of a structural system and operational system
- ◆ briefly describe two fault diagnostic methods
- ◆ describe industrial machine maintenance techniques of planned maintenance and preventative maintenance, and how each method can be used to maximum benefit
- ◆ identify the benefits of industrial systems maintenance recording
- ◆ describe the principle of operation of data loggers and discuss the benefits in terms of retrieving trend data
- ◆ describe one system monitoring technique

The assessment of this Outcome should be combined with that of Outcomes 1, 2 and 3 to form one assessment paper. This single assessment paper should be taken at a single assessment event lasting no more than two hours and carried out under supervised, controlled conditions. Assessment should be conducted under closed-book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates should be permitted to use scientific calculators during the assessment.

Assessment guidelines

Questions in the assessment can be composed of a suitable balance of short answer, restricted response and structured questions.

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Administrative Information

Unit code:	HT79 48
Unit title:	Industrial Systems
Superclass category:	VE
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FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our [Centre Feedback Form](#).

SQA Advanced Unit specification: support notes

Unit title: Industrial Systems

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

This Unit has been written in order to allow candidates to develop knowledge and understanding in the following engineering areas:

- 1 Analyse a variety of industrial systems.
- 2 Describe the principle of operation of measurement devices used in industrial systems.
- 3 Identify the control techniques used in industrial systems and explain the operation of control algorithms, software and hardware used to achieve system control.
- 4 Describe the concepts and methods involved in condition monitoring of industrial systems.

This Unit has been written with a view to giving an overview of industrial systems for candidates who may be involved in an engineering environment. However, it does not preclude its use in other awards where the award designers feel this to be appropriate.

In designing this Unit, the Unit writer has identified the range of topics that would be expected to be covered by lecturers. Recommendations are also given as to how much time should be spent on each Outcome. This has been done to help lecturers to decide what depth of treatment should be given to the topics attached to each of the Outcomes. Whilst it is not mandatory for centres to use this list of topics, it is recommended that they do so to ensure consistency of learning and teaching across the Outcomes.

A list of topics for each Outcome is given below.

1 Analyse a variety of industrial systems. (10 hours)

- ◆ Industrial Safety Requirements for industrial systems. An understanding of how industrial systems assist, help and support current industry standards (including HASWA, COSHH, ATEX, certificate of conformity, permit to work, manual handling etc), how they are designed and help to assist company requirements.
- ◆ Mechanical and machine systems: mechanical handling, conveyors, industrial automation systems.
- ◆ Electrical interaction: standardised signals (I/P, P/I, I/E, E/I), electro-hydraulic, electro-pneumatic, electro-mechanical, electrical safety (guarding), IP rating, applications.
- ◆ Pneumatic systems and operation: working principles, simple circuits, advantages and disadvantages, applications.
- ◆ Vacuum machine systems: vacuum pumps, circuitry, applications.
- ◆ Industrial machine development: compare historic and current technology within an industrial environment (eg conventional control systems compared to current computer controlled systems).
- ◆ Construct block diagrams to show typical industrial systems: typical systems may include mechanical handling, conveying, electro-mechanical etc.

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2 Describe the principle of operation of measurement devices used in industrial systems. (10 hours)

- ◆ Mechanical and electrical measurement: speed, flow, pressure, temperature, voltage, current and resistance.
- ◆ Operation and uses of sensors and transducers: principles of operation of optical and mechanical types (Why limit to these two types only?).
- ◆ Common techniques of A/D and D/A conversion: principle of operation.
- ◆ Overview of the operational characteristics of industrial system controllers
 - Micro-controller
 - PLC
 - Computer control systems
 - SCADA Systems
 - Distributed Control System
- ◆ Selection of suitable sensors and actuators.

3 Identify the control techniques used in industrial systems and explain the operation of control algorithms, software and hardware used to achieve system control. (10 hours)

- ◆ Design of industrial system control including software and hardware: explanation of system control, principle of operation of software and hardware.
- ◆ Open and closed loop systems: typical output responses.
- ◆ Explanation of mimic diagrams and process flow diagrams: principle and overview of current technology systems.
- ◆ Control terminology: explanation of resolution and accuracy. Control terminology including the following resolution, accuracy, hysteresis, linearity, drift and dead zone.
- ◆ Control techniques including sequential control (event and timed functions), two step control, Proportional, Integral and Derivative (PID) control algorithm, critically tuned systems, fuzzy logic and neural networks (practical examples of fuzzy logic).
- ◆ Explanation of predictive techniques for improving digital signals.

4 Describe the concepts and methods involved in condition monitoring of industrial systems. (10 hours)

- ◆ Explain industrial machine health.
- ◆ Explain fault diagnostic methods: noise, half split, end to end and random, approved strip and rebuild methods.
- ◆ Industrial machine maintenance: Reactive Maintenance (R.M), Planned Preventative Maintenance (PPM).
- ◆ Industrial systems maintenance recording: maximising effectiveness, record keeping data and time scales, historical data and interaction of maintenance into production.
- ◆ Data logging systems and applications: principle of operation and overview.
- ◆ Systems monitoring techniques: principle of operation and explanation of equipment.
- ◆ Systems monitoring techniques include the following techniques:
 - Vibration analysis
 - Noise level measurement
 - Magnetic plug inspection
 - Ferrograph precipitation
 - X-Ray spectrometry
 - Gas chromatography
 - Heat emission analysis and distinguish temperature measurement techniques; recordable data, temperature explanation and sensing equipment.

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Guidance on the delivery and assessment of this Unit

This Unit should be delivered by a combination of lecturing and whole class and group discussions. In order to make the subject as interesting as possible centres are encouraged to use practical examples, manufacturers' literature, relevant software and videos. Candidates should also be encouraged to explore the Internet for information on various industrial systems.

Practical demonstrations, industrial visits or laboratory exercises in aspects of industrial systems should be provided throughout the Unit.

A range of transducers, actuators and control systems should be available for candidates to view.

Centres should also use group discussions to allow candidates to select and justify industrial systems for different applications.

The written assessment should take place after all Outcomes have been completed.

Opportunities for developing Core Skills

There may be opportunities to gather evidence towards the following listed Core Skill components in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Written Communication	SCQF level 6
Use of Numbers	SCQF level 6
Oral Communication	SCQF level 6
Critical Thinking	SCQF level 6
Reviewing and Evaluating	SCQF level 6
Working with Others	SCQF level 6

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of tutor support. However, with regard to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would have to be put in place to ensure the assessments were conducted under controlled supervised conditions.

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.

General information for candidates

Unit title: Industrial Systems

This Unit has been designed to allow you to develop knowledge and understanding of industrial systems and explain how they operate in terms of what they are, how they work and how they are put together.

The early part of the Unit deals with system requirements, development, mechanical and electrical interaction and industrial standards. The next stage of the Unit takes you through the principle of operation of transducers, actuators and controllers. You will then be provided with an opportunity to develop your knowledge and understanding of control techniques and the software and hardware used to achieve control of industrial systems. Finally you will cover fault diagnostic methods, preventive maintenance and planned maintenance and conditioning monitoring techniques used in the analysis of systems before they breakdown.

The formal assessment for this Unit consists of a single assessment paper covering all four Outcomes lasting no more than two hours. The assessment paper will be conducted under closed-book conditions. You will not be allowed to take notes, textbooks etc. into the assessment, however you will be allowed to use a scientific calculator. You will sit this assessment paper at the end of the Unit.