

SQA Advanced Unit Specification

General information for centres

Unit title: Complex Control Systems

Unit code: HV61 47

Unit purpose: This Unit is designed to enable candidates to gain knowledge and understanding of process control technology and apply that knowledge to industrial situations.

On completion of this Unit the candidates should be able to:

- 1 Explain the operation of complex control systems.
- 2 Explain boiler control systems.
- 3 Explain compressor control systems.
- 4 Explain distillation column control systems.

Credit points and level: 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*)

**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: Access to this Unit will be at the discretion of the centre and the following recommendations are for guidance only. Candidates should have a basic knowledge of Measurement and Control Engineering. This may be evidenced by the possession of Higher Process Measurement or Higher Process Control or NQ Units in Measurement and Control or NC Measurement and Control or NC Multidisciplinary Engineering.

Core Skills: There are opportunities to develop the Core Skills of Written Communication (Writing), Written Communication (Reading) and Problem Solving (Critical Thinking) at SCQF level 5 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

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.

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Assessment: All assessments could be assessed holistically with an integrated end of Unit assessment lasting approximately 3 hours. Alternatively Outcomes 1, 2, 3 and 4 could be assessed individually. Each individual assessment should last approximately 1 hour. The assessment papers should be composed of a balance of short answer, restricted response and structured questions. The assessments should be conducted under controlled supervised conditions.

Unit specification: statement of standards

Unit title: Complex Control 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

Explain the operation of complex control systems

Knowledge and/or skills

- ◆ Feed-forward control
- ◆ Cascade control
- ◆ Ratio control
- ◆ Multi-variable control

Evidence Requirements

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

Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above.

In any assessment of this Outcome three out of the four knowledge and/or skills should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of three out of the four knowledge and/or skills 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 with the aid of a sketch the operation of a feed-forward control system
- ◆ explain with the aid of a sketch the operation of a cascade control system
- ◆ explain with the aid of a sketch the operation of a ratio control system
- ◆ explain with the aid of a sketch the operation of a multi-variable control system

Evidence should be generated through assessments undertaken in controlled supervised conditions.

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Assessment guidelines

Assessments should be conducted under closed book conditions and as such candidates must not be allowed any text books, handouts or notes in the assessment. Questions used to elicit candidate evidence may take the form of short answer or restricted response questions.

All Outcomes could be assessed holistically with an integrated end of Unit assessment lasting approximately 3 hours. Alternatively Outcome 1 could be assessed individually. The individual assessment should last approximately 1 hour.

Outcome 2

Explain boiler control systems

Knowledge and/or skills

- ◆ Boiler types
- ◆ Control of water level, feedwater, steam pressure, fuel and air, super heat and reheat temperatures
- ◆ Single element, two element and three element control
- ◆ Combustion control
- ◆ Measuring of excess air, oxygen and carbon monoxide

Evidence Requirements

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

Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above.

In any assessment of this Outcome four out of the five knowledge and/or skills should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of four out of the five knowledge and/or skills 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:

- ◆ explain with the aid of a sketch one type of boiler
- ◆ explain the operation and control of the boiler inputs and outputs
- ◆ explain single element, two element and three element control on a boiler
- ◆ explain series/parallel methods of combustion control
- ◆ explain how excess air, oxygen and carbon monoxide can be measured

Evidence should be generated through assessments undertaken in controlled supervised conditions.

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Assessment guidelines

Assessments should be conducted under closed book conditions and as such candidates must not be allowed any text books, handouts or notes in the assessment. Questions used to elicit candidate evidence may take the form of short answer or restricted response questions.

All Outcomes could be assessed holistically with an integrated end of Unit assessment lasting approximately 3 hours. Alternatively Outcome 2 could be assessed individually. The individual assessment should last approximately 1 hour.

Outcome 3

Explain compressor control systems

Knowledge and/or skills

- ◆ Types of compressors
- ◆ Fixed speed and variable speed compressors
- ◆ Flow/ pressure drop characteristics
- ◆ PI diagrams
- ◆ Surge control
- ◆ Compressor configurations

Evidence Requirements

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

Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above.

In any assessment of this Outcome four out of the six knowledge and/or skills should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of four out of the six knowledge and/or skills 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:

- ◆ compare two different types of compressor
- ◆ explain with the aid of a sketch the operation of a centrifugal compressor
- ◆ explain flow/pressure drop characteristics
- ◆ complete a P/I diagram
- ◆ explain how surge can be controlled
- ◆ compare compressors in parallel and in series

Evidence should be generated through assessments undertaken in controlled supervised conditions.

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Assessment guidelines

Assessments should be conducted under closed book conditions and as such candidates must not be allowed any text books, handouts or notes in the assessment. Questions used to elicit candidate evidence may take the form of short answer or restricted response questions.

All Outcomes could be assessed holistically with an integrated end of Unit assessment lasting approximately 3 hours. Alternatively Outcome 3 could be assessed individually. The individual assessment should last approximately 1 hour.

Outcome 4

Explain distillation column control systems

Knowledge and/or skills

- ◆ Basic principles of distillation
- ◆ Operation of a distillation tower
- ◆ P/I diagrams
- ◆ Reflux operation
- ◆ Control systems
- ◆ Quality control

Evidence Requirements

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

Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above.

In any assessment of this Outcome four out of the six knowledge and/or skills should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of four out of the six knowledge and/or skills 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:

- ◆ explain the basic principles of distillation
- ◆ explain the operation of a distillation tower
- ◆ complete a P/I diagram for a distillation tower
- ◆ explain the use of reflux
- ◆ explain the control systems for a distillation column
- ◆ explain factors that may affect quality

Evidence should be generated through assessments undertaken in controlled supervised conditions.

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ASS Assessments should be conducted under closed book conditions and as such candidates must not be allowed any textbooks, handouts or notes in the assessment. Questions used to elicit candidate evidence may take the form of short answer or restricted response questions.

All Outcomes could be assessed holistically with an integrated end of Unit assessment lasting approximately 3 hours. Alternatively Outcome 4 could be assessed individually. The individual assessment should last approximately 1 hour.

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Administrative information

Unit code:	HV61 47
Unit title:	Complex Control Systems
Superclass category:	VG
Original date of publication:	November 2017
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History of Changes:

Version	Description of change	Date

Source: SQA

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Unit specification: support notes

Unit title: Complex Control 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, understanding and skills in the following areas:

- 1 Complex control systems.
- 2 Boiler control systems.
- 3 Compressor control systems.
- 4 Distillation column control systems.

The Unit is at SCQF level 7 and the Unit has been developed as part of the SQA Advanced Certificate/Diploma in Measurement and Control Engineering. However this does not preclude the use of this Unit in other awards where award designers feel it is appropriate.

In designing this Unit, the writer has identified the range of topics that they would expect to be covered by lecturers. The writer has also given recommendations as to how much time should be spent on each Outcome. This is done to help lecturers to decide what depth of treatment should be given to the topics attached to each Outcome.

A list of topics for each Outcome is given below. The knowledge and/or skills of Outcome 1 could be supported with practicals.

Outcome 1

Complex control systems (9 hours)

- ◆ Feed-forward control
- ◆ The advantages of using feed-forward control for process load disturbances
- ◆ Limitations of using feed-forward control
- ◆ Examples of feed-forward control (eg heat exchangers)
- ◆ Energy balance equations
- ◆ Cascade control
- ◆ Primary and secondary loops
- ◆ Advantages and disadvantages of cascade control
- ◆ Control modes used in primary and secondary controllers
- ◆ Control mode selection and tuning
- ◆ Examples of cascade control (eg level control)
- ◆ Ratio control
- ◆ P/I diagrams and block diagrams
- ◆ Controller types
- ◆ Ratio control with feedback trim
- ◆ Loop signal values for ratio flow loops

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- ◆ Difference between linear and square station
- ◆ Use of two input multiplier
- ◆ Examples of ratio control (e.g. blending operations)
- ◆ Multi-variable control
- ◆ P/I diagrams
- ◆ Interaction between loops (e.g. pressure and flow)
- ◆ Controllability
- ◆ Coupling between loops
- ◆ Extremes of interaction and how this can be improved

Outcome 2

Explain boiler control systems (9 hours)

- ◆ Boiler theory
- ◆ Types of boiler (fire tube, water tube)
- ◆ Boiler controls:
 - Control of water level
 - Feedwater
 - Steam pressure
 - Fuel and air
 - Superheat and reheat temperatures
- ◆ Types of control
 - Single element
 - Two element
 - Three element
- ◆ Combustion control
 - Series
 - Parallel
 - Series/parallel
- ◆ Measuring excess air, oxygen and carbon monoxide
- ◆ P/I diagrams

Outcome 3

Explain compressor control systems (9 hours)

- ◆ Types of compressors (centrifugal, reciprocating and axial flow)
- ◆ Compressor controls
- ◆ Fixed speed and variable speed compressors
- ◆ Flow and pressure drop characteristics
- ◆ P/I diagrams
- ◆ Surge in compressors:
 - Use of surge control line
 - Anti-surge systems
 - Capacity control
 - De-coupling of anti-surge and capacity control
- ◆ Automatic start-up and shutdown
- ◆ Compressors in series to increase pressure
- ◆ Compressors in parallel to increase capacity

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Outcome 4

Explain distillation column control systems (9 hours)

- ◆ Basic distillation theory
- ◆ Operation of a distillation column
- ◆ Use of vapour pressure to control column
- ◆ Use of reflux
- ◆ Control of reflux:
 - Reflux rate
 - Reflux ratio
- ◆ Methods of condenser operation:
 - Flooded condenser
 - Partial condenser
- ◆ Factors that affect quality:
 - Flooded tray/dry trays
 - Thermal balance control
 - Material balance control
- ◆ Tower temperature profile
- ◆ Temperature control of a distillation column
- ◆ Examples of column control:
 - Pressure, overheads rate and composition
 - Pressure, bottoms rate and composition
 - Pressure, bottoms rate and overhead composition with partial condenser
 - Pressure, overheads rate and bottom composition
 - Pressure, bottoms rate, overheads rate and composition
- ◆ P/I diagrams

All assessments could be assessed holistically with an integrated end of Unit assessment lasting approximately 3 hours. Alternatively Outcomes 1, 2, 3 and 4 could be assessed individually. Each individual assessment should last approximately 1 hour. The assessment papers should be composed of a balance of short answer, restricted response and structured questions. The assessments should be conducted under controlled supervised conditions

Guidance on the delivery and assessment of this Unit

This Unit is designed to enable candidates to gain knowledge and understanding of process control technology and apply that knowledge to industrial situations.

In the delivery candidates should have access to diagrams for compressors, boilers and distillation columns.

The content of the four Outcomes means that they are not a direct follow on to each other and hence they could be delivered in any order. Due to the range of topics covered in each Outcome it is recommended that each Outcome is assessed, with a separate paper, at the end of the delivery for that Outcome.

Opportunities for developing Core Skills

There are opportunities to develop the Core Skills of Written Communication (Writing), Written Communication (Reading) and Problem Solving (Critical Thinking) at SCQF level 5 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

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Open learning

This Unit could be delivered by distance learning that may incorporate some degree of on-line support.

However it would require planning by the centre to ensure the sufficiency and authenticity of candidate evidence. Agreements would have to be made to ensure that a single assessment for the end test is delivered in a supervised environment under controlled conditions.

To keep the administrative burden to a minimum, it is recommended that a single end test is used for distance learning candidates.

For information on open learning, please refer to *SQA guide assessment and quality assurance of open and distance learning (A1030, Feb 2001)*.

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: Complex Control Systems

This Unit has been designed to provide you with knowledge and skills that will enable you to understand how processes are controlled. You will refer to process diagrams throughout this Unit. The Unit will be assessed using four separate assessments, each one lasting approximately one hour. Alternatively the assessments can be integrated into an end of Unit assessment lasting 3 hours. You will not be allowed to take notes, handouts, textbooks, etc. into the assessment.

In Outcome 1 you will learn about complex control systems, how they operate and the advantages of using them.

In Outcome 2 you will learn how some types of boilers work. You will learn about the control of various parameters of boilers and how that control is implemented.

In Outcome 3 you will learn how some types of compressors work. You will learn about the control of various parameters of compressors and how that control is implemented.

In Outcome 4 you will learn how some types of distillation columns work. You will learn about the control of various parameters of distillation columns and how that control is implemented.