

## SQA Advanced Unit Specification

### General information for centres

**Unit title:** Safe Instrumentated Systems

**Unit code:** HV6H 48

**Unit purpose:** This Unit is designed to enable candidates to gain knowledge and understanding and apply Safe Instrumentated Systems (SIS) in Industrial Measurement and Control engineering.

On completion of the Unit candidates should be able to:

- 1 Explain safe instrumentated systems.
- 2 Apply risk reduction and logic solvers.
- 3 Analyse safe integrity limits (SIL).
- 4 Analyse safety in field instrument devices.

**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:** Access to this Unit will be at the discretion of the centre and the following recommendations are for guidance only. Candidates should have a wide knowledge of Measurement and Control Engineering. This could be evidenced by the possession of the SQA Advanced Units: HV63 47 Distributed Control Systems and HV67 47 Measurement Systems 1. There could also be an advantage of possessing or working towards the SQA Advanced Units HT1K 47 Applications and Programmable Logic Controllers, HV65 47 Instrumentation in Hazardous Areas and HP3G 47 Combinational Logic.

**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:** The assessments for Outcomes 1, 2, 3 and 4 can be assessed separately of one hour duration each OR alternatively integrated into a single assessment paper. The integrated assessment paper should be taken by candidates at one single assessment event and should last approximately three hours. The integrated assessment paper should be composed of a balance of short answer questions, restricted response questions and structured questions.

The integrated assessment should be carried out towards the end of Unit delivery. Candidates must achieve all minimum evidence specifications for each Outcome in order to pass the Unit.

### Unit specification: statement of standards

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**Unit code:** HV6H 48

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 safe instrumentated systems

#### Knowledge and/or skills

- ◆ Definition of a safe instrumentated system
- ◆ Safety related systems for equipment under control
- ◆ Introduction to hazard, risk, risk reduction and concept of “as low as reasonably possible”
- ◆ Process control versus safety control
- ◆ Layers of protection

#### 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 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 five 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:

- ◆ define a safe instrumentated system
- ◆ apply safety related systems for equipment under control
- ◆ apply hazard, risk, risk reduction and concept of “as low as reasonably possible” (ALARP)
- ◆ explain the difference between process control and safety control as in hazardous areas
- ◆ explain layers of protection relating to the operation of a hazardous complex

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. This Outcome can be assessed separately of approximately one hour duration or integrated with Outcomes 2, 3 and 4 and should last approximately three hours.

### **Outcome 2**

Apply risk reduction and logic solvers

#### **Knowledge and/or skills**

- ◆ Basic reliability analysis
- ◆ SIS configurations and shared technology functions
- ◆ Design of safety PLC and process safety time
- ◆ Redundancy systems and dual redundant channel safety PLC architecture
- ◆ Communication factors for safety controllers
- ◆ Generation/production of the logic for logic solver and applications to process control
- ◆ Examples of simple and complex shut down sequences

#### **Evidence Requirements**

Evidence for the knowledge and 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 question based on a sample of the items above. In any assessment of this Outcome five out of seven 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 five knowledge and /or skills is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all items. Where sampling takes place a candidate 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:

- ◆ apply reliability analysis
- ◆ explain SIS configurations and the technology used
- ◆ explain the design of a safety PLC and process safety time
- ◆ explain redundancy systems and redundant channel safety PLC architecture
- ◆ explain communications in safety controllers
- ◆ apply logic for logic solvers used in process control applications
- ◆ apply shut down sequences in process control

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

### **Assessment guidelines**

Assessments should be conducted under closed book conditions and as such candidates must not be allowed to bring textbooks, handouts, manuals or notes to the assessment.

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Questions used to elicit candidate evidence may take the form of short answer or restricted response questions. This Outcome can be assessed separately of approximately one hour duration or integrated with Outcomes 1, 3 and 4 and should last approximately three hours.

### Outcome 3

Analyse safe integrity limits (SRL)

#### Knowledge and/or skills

- ◆ Safety integrity levels based on IEC 61508
- ◆ Quantitative method of SIL determination
- ◆ Safety requirement specification (SRS)
- ◆ Risk graph method
- ◆ SIL classification by hazardous event matrix

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

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

When sampling takes place a candidate response can be judged satisfactory where evidence provided is sufficient to meet the requirement for each item by showing that the candidate is able to:

- ◆ explain SIL according to IEC 61508 or equivalent
- ◆ analyse quantitative methods of SIL evaluation
- ◆ explain safety requirement specifications
- ◆ analyse risk graph methods
- ◆ analyse SIL using an event matrix

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

#### Assessment guidelines

Assessments should be conducted under closed book conditions and as such candidates must not be allowed to bring textbooks, handouts, manuals or notes to the assessment.

Questions used to elicit candidate evidence may take the form of short answer or restricted response questions. This Outcome can be assessed separately of approximately one hour duration or integrated with Outcomes 1, 2 and 4 and should last approximately three hours.

### Outcome 4

Analyse safety in field instrument devices

#### Knowledge and/or skills

- ◆ Reliability and failure cause in field devices
- ◆ Techniques to minimise failure for actuator types
- ◆ Redundancy in sensors, transmitters and actuators and fault tolerance of sub systems
- ◆ Separation of measurement system from process control system
- ◆ Use of Hart transmission systems and field bus communications within an SIS application
- ◆ Safety certified valve positioners

#### 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 samples of the items above. In any assessment of this Outcome five out of six knowledge and/or skills items should be sampled.

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

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

- ◆ compare reliability and failure cause in field devices
- ◆ explain techniques to minimise failure for actuator types
- ◆ analyse redundancy in sensors, transmitters, actuators and fault tolerance of sub systems
- ◆ explain separation of measurement systems from process control systems
- ◆ analyse Hart transmission systems and field bus communications within an SIS system
- ◆ explain safety certified valve positioners

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

#### Assessment guidelines

Assessments should be conducted under closed book conditions and as such candidates must not be allowed to bring textbooks, handouts, manuals or notes to the assessment.

Questions used to elicit candidate evidence may take the form of short answer or restricted response questions. This Outcome can be assessed separately of approximately one hour duration or integrated with Outcomes 1, 2 and 3 and should last approximately three hours.

## SQA Advanced Unit Specification

### Administrative information

<b>Unit code:</b>	HV6H 48
<b>Unit title:</b>	Safe Instrumentated Systems
<b>Superclass category:</b>	VD
<b>Original date of publication:</b>	November 2017
<b>Version:</b>	01

### History of Changes:

Version	Description of change	Date

**Source:** SQA

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### Unit specification: support notes

#### Unit title: Safe Instrumentated 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

The Unit has been written to allow candidates to develop knowledge, understanding and skills in the following areas

- 1 The application of safe instrumentated systems.
- 2 Risk reduction and logic solvers.
- 3 Analysis of safe integrity limits.
- 4 Analysis of safety in field instrument devices.

The Unit is at SCQF level 8 and the Unit has been developed for the new SQA Advanced Diploma in Measurement and Control Engineering award. However this does not preclude the use of this Unit in other awards where 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 lectures. 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. Lecturers are advised to study the list in conjunction with the assessment exemplar pack so that they can get a clear indication of the standards of achievement expected of candidates in the Unit.

#### Outcome 1

Explain safe instrumentated systems (6 hours)

- ◆ Definition of safe instrumentated systems. Block diagram of the system including the logic solver
- ◆ Safety related systems for equipment under control- scope of equipment under control
- ◆ Safety life cycle model and its phases and description
- ◆ Introduction to hazard, risk and risk reduction, tolerable risk and ALARP
- ◆ Fatal accident rate and individual risk
- ◆ Safety systems engineering- fundamental safety
- ◆ Process control versus safety control
- ◆ Layers of protection



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### Outcome 2

Apply risk reduction and logic solvers (12 hours)

- ◆ Basic reliability analysis applied to safety systems
- ◆ Mean time between failures, mean time to fail, risk reduction factor, safety availability, probability of failure on demand, hazard rate, demand rate, proof of test interval, auto diagnostic period, failure rate, fail to danger rate, coverage and common cause factor
- ◆ Technologies for logic solvers - Basic SIS configurations, shared functions, pneumatics, relays, trip amplifiers, safety relays, solid state systems, programmable systems (PLCs), overall reliability, and software reliability. Hardware/software characteristics of safety PLC. Design of safety PLC. Process safety time. Dual redundant channel safety PLC architecture. Triple modular redundancy systems. Communication factors for safety controllers (TCP/IP). Networks for PLC interfaces. Examples of simple and complex shut down sequences. Generation/production of the logic for the logic solver and applications to process control

### Outcome 3

Analyse safe integrity limits (9 hours)

- ◆ Concept of safety integrity level (SIL)
- ◆ Safety integrity based on IEC 61508
- ◆ Quantitative methods of SIL determination
- ◆ Evaluation of SIS requirements and process safety times
- ◆ Hazop methods
- ◆ Safety requirement specification SRS — development of SRS, quantitative method and risk graph method
- ◆ SIL classification by hazardous event matrix

### Outcome 4

Analyse safety in field instrument devices (9hours)

- ◆ Sensors, actuators and transmitters - reliability, potential cause of failure and failure modes
- ◆ Actuator types — potential cause of failure in final control element and remotely operated shut-off valves. Techniques to minimise failure and design for fail safe operations
- ◆ Separation of sensors from basic process control system
- ◆ Redundancy in sensors and actuators and fault tolerance of sub systems
- ◆ Comparison of redundancy options, application using Hart transmission and field bus communications within an SIS application
- ◆ Safety certified valve positioners

### Unit Assessment

Written paper (combined) 3 hours.

### Guidance on the delivery and assessment of this Unit

It is intended that this Unit is presented in the context of applying safe instrumentated systems in industrial measurement and control engineering and is designed to provide candidates with technical knowledge and skills for the occupational area in which they are involved.

Assessment will be by individual Outcome OR by one end assessment where the end assessment integrates the assessments for each Outcome.

Assessments should be held in controlled conditions and candidates may not bring textbooks, handouts or any material prepared by themselves to the end of Unit assessment.

#### *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 Skill components.

### Open learning

The Unit could be delivered by distance learning. 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](http://www.sqa.org.uk/assessmentarrangements).

## **SQA Advanced Unit Specification**

### **General information for candidates**

#### **Unit title:** Safe Instrumentated Systems

This Unit has been designed to provide you with knowledge and understanding and skills that will enable you to understand the basis of safe instrumentated systems and its application to process measurement and control.

The Unit will allow you to develop knowledge and understanding of risk analysis and logic solvers and their technology, safe integrity limits and their evaluation and the application of safety to field devices.

The written assessments will take place under controlled supervised conditions and you will not be allowed to take notes, handouts or textbooks to the assessment.

The assessment can be carried out on an Outcome by Outcome basis or alternatively the Outcomes can be integrated into a single assessment carried out at the end of the Unit.