

## SQA Advanced Unit Specification

### General information for centres

**Unit title:** Risk Analysis, Reliability and Loss Prevention in Measurement and Control Engineering

**Unit code:** HV6A 47

**Unit purpose:** This Unit is designed to enable candidates to gain knowledge and understanding of risk analysis, reliability, and loss prevention applied to process control systems by being able to understand and apply the operation, and know the applications of the different types of risk analysis, reliability, and loss prevention techniques that are applied to Measurement and Control Systems and devices.

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

- 1 Explain the meaning of reliability and how to improve reliability of measurement and control systems.
- 2 Explain the maintainability as applied to measurement and control systems.
- 3 Explain latent fault and trip systems.
- 4 Analyse risk by use of reliability and loss prevention techniques.

**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) and Written Communication (Reading) 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 assessment for Outcome 1, 2 and 3 in this Unit should be combined together into one written assessment paper. This paper should be taken by candidates at one single assessment event that should last approximately two hours. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions.

This assessment should be conducted under controlled, supervised conditions.

The assessment should be carried out at the end of the delivery of the Unit.

Evidence of candidate knowledge for Outcome 4 will be an assignment in which they are given a simple control system to carry out a Risk Analysis/Reliability study on. The report should be a minimum of 500 words long. Candidates should complete the assignment in five hours.

It should be noted that the candidates must achieve all the minimum evidence specified for each Outcome in order to pass the Unit.

**Unit specification: statement of standards**

**Unit title:** Risk Analysis, Reliability and Loss Prevention in Measurement and Control Engineering

**Unit code:** HV6A 47

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 meaning of reliability and how to improve reliability of measurement and control systems

**Knowledge and/or skills**

- ◆ The meaning of reliability
- ◆ Methods of analysis of reliability
- ◆ Statistical methods of reliability analysis

**Evidence Requirements**

Candidates will need evidence to demonstrate their knowledge and/or skills in this Outcome which 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 two out of three knowledge and/or skills each time the Outcome is assessed. Candidates must provide a satisfactory response to both 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 reliability
- ◆ explain methods of analysis of reliability
- ◆ explain statistical methods of reliability analysis

Evidence should be generated through assessment undertaken in controlled supervised conditions. Assessments should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks or handouts to the assessment.

**Assessment guidelines**

The assessment paper for Outcomes 1, 2 and 3 should be taken at a single assessment event lasting two hours. Such a paper should be composed of an appropriate balance of short answer, restricted response and structured questions covering all the elements listed under the knowledge and skills.

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In order to ensure that candidates will not be able to foresee what type of questions they will be questioned on, a different sample of questions are required each time the Outcome is assessed.

Evidence should be generated through assessment undertaken in controlled supervised conditions. Assessments should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks, handouts or non-programmable calculators to the assessment

### Outcome 2

Explain maintainability as applied to measurement and control systems

#### Knowledge and/or skills

- ◆ The meaning of maintainability
- ◆ The meaning of ‘mean time to repair’
- ◆ The meaning of ‘mean maximum repair time’
- ◆ Methods of analysis of maintainability

#### Evidence Requirements

Candidates will need evidence to demonstrate their knowledge and/or skills in this Outcome which 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 three out of four knowledge and/or skills items 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 maintainability
- ◆ explain the meaning of ‘mean time to repair’
- ◆ explain the meaning of ‘mean maximum repair time’
- ◆ explain Methods of analysis of maintainability

#### Assessment guidelines

The assessment paper for Outcomes 1, 2 and 3 should be taken at a single assessment event lasting approximately two hours. Such a paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

In order to ensure that candidates will not be able to foresee what type of questions they will be questioned on, a different sample of questions are required each time the Outcome is assessed.

Evidence should be generated through assessment undertaken in controlled supervised conditions. Assessments should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks, handouts or non-programmable calculators to the assessment.

## **Outcome 3**

Explain latent fault and trip systems

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

- ◆ Probability laws
- ◆ The frequency and rate per calendar time/operating time
- ◆ Protection System Failure's
- ◆ The probability of fractional dead time and of failure of voting systems

### **Evidence Requirements**

Candidates will need evidence to demonstrate their knowledge and/or skills in this Outcome which 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 three out of four 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 Probability laws
- ◆ explain the Frequency and rate per calendar time/operating time
- ◆ explain Protection System Failure's
- ◆ explain the probability of fractional dead time and of failure of voting systems

### **Assessment guidelines**

The assessment paper for Outcomes 1, 2 and 3 should be taken at a single assessment event lasting approximately two hours. Such a paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

In order to ensure that candidates will not be able to foresee what type of questions they will be questioned on, a different sample of questions are required each time the Outcome is assessed.

Evidence should be generated through assessment undertaken in controlled supervised conditions. Assessments should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks, handouts or non-programmable calculators to the assessment

## **Outcome 4**

Analyse risk by use of reliability and loss prevention techniques

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

- ◆ Failure rate synthesis of a given control system
- ◆ Effects of environmental and stress on failure rate of a given control system
- ◆ Evaluation of failure rate per year of a synthesised control system
- ◆ Maintainability of a given control system
- ◆ Reliability of a given control system

### **Evidence Requirements**

Candidates will need evidence to demonstrate that all of the knowledge and/or skills in this Outcome have been assessed. The evidence may be provided in response to specific questions. Candidates must provide a satisfactory response to all five knowledge and/or skills.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each knowledge and/or skill by showing that the candidate is able to:

- ◆ analyse failure rate synthesis of a given control system
- ◆ analyse effects of environmental and stress on failure rate of a given control system
- ◆ analyse evaluation of failure rate per year of a synthesised control system
- ◆ analyse maintainability of a given control system
- ◆ analyse Reliability of a given control system

### **Assessment guidelines**

Evidence of candidate knowledge will be an assignment in which they are given a simple control system on which to carry out a Risk Analysis/Reliability study. A typical example being, the candidate is given a temperature control loop, sensor/transmitter, controller and valve positioner/valve for which a full reliability analyses has to be carried out.

Candidates must provide a satisfactory response to all five knowledge and/or skills.

The report should be a minimum of 500 words long. Candidates should complete the assignment in five hours.

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### Administrative information

<b>Unit code:</b>	HV6A 47
<b>Unit title:</b>	Risk Analysis, Reliability and Loss Prevention in Measurement and Control Engineering
<b>Superclass category:</b>	VD
<b>Original date of publication:</b>	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:** Risk Analysis, Reliability and Loss Prevention in Measurement and Control Engineering

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 Explain the meaning of reliability and how to improve reliability of measurement and control systems.
- 2 Explain the maintainability as applied to measurement and control systems.
- 3 Explain latent fault and trip systems.
- 4 Analyse risk by use of reliability and loss prevention techniques.

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 award. 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.

#### **Outcome 1 (10 hours)**

- ◆ Reliability: Fault, failure, failure rate, mean time to failure and mean time between failures. Reliability as a probability, unreliability.
- ◆ Reliability block diagrams. Failure mode and effect analysis (FMEA). Fault trees, event trees, maintenance task trees, maintainability prediction and simulation. Failure probability, Hours and their meaning, Venn diagrams, rules of Boolean algebra, fault tree rules and block diagram rules.
- ◆ Combining reliability and availability, human factors, human reliability.
- ◆ Improving reliability.
- ◆ Minimise failures, system simplification, decrease component count, use of fault.
- ◆ Tolerance, use of preventive maintenance, use of corrective maintenance.
- ◆ Design improvement quality control common mode failures, cascade failures.
- ◆ Parallel redundancy (hot/cold standby. Majority voting).
- ◆ Statistics: exponential. Weibull, Rayleigh and bathtubs.

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### Outcome 2 (6 hours)

- ◆ Meaning of maintainability, mean time to repair, mean maximum repair time.
- ◆ Preventative/corrective maintenance, quantitative maintenance analysis-maintenance process and qualitative prediction.

### Outcome 3 (9 hours)

- ◆ Probability Laws — independent, conditional, mutually exclusive and non-exclusive. Frequency and rate per calendar time/operating time.
- ◆ Protection System Failures fail safe fail to danger fractional dead time (FDT).
- ◆ Probability of FDT, probability of failure and two out of three voting systems.
- ◆ Hazard rate and methods of optimising FDT.

### Outcome 4 (10 hours)

- ◆ Failure rate synthesis of plant components. Failure data for valves, instruments, pumps, pipe work, vessels and control loops, effects of environment and stress on failure rate. Failure rate of pneumatic control valves, pressure relief valves. Solenoid Operated valves (SOVs).
- ◆ Pressure - switches, transmitter,  $\Delta P$  transmitter, variable area meter switches.
- ◆ Temperature - switch, thermocouple/resistance thermometer transmitter/indicator.
- ◆ Flow - switches, transmitters,  $\Delta P$  transmitters and variable area meter.
- ◆ Level - float switch. Indicator, capacitance probe and  $\Delta P$  transmitter.
- ◆ Control loops - (pressure temperature, level and flow) data for hazardous failures and for the whole loop (sensor/transmitter controller activator and connection).
- ◆ Pumps: centrifugal, firewater and electric driven.
- ◆ Pipe work - metal straight/plastic; hoses impulse lines, bellows.
- ◆ Vessels — heat exchangers, atmospheric metal/ non-metallic, pressurised metallic.
- ◆ Evaluation of failure rate per year of synthesised plant equipment.

### Unit Assessment

The assessment for Outcome 1, 2 and 3 in this Unit should be combined together into one written assessment paper. This paper should be taken by candidates at one single assessment event that should last approximately two hours. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions.

This assessment should be conducted under controlled, supervised conditions.

The assessment should be carried out at the end of the delivery of the Unit.

Evidence of candidate knowledge for Outcome 4 will be an assignment in which they are given a simple control system to carry out a Risk Analysis/ Reliability study on. The report should be a minimum of 500 words long. Candidates should complete the assignment in five hours.

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

This Unit has been written to incorporate sufficient time to allow the lecturer to teach, in a student centred way, the factors that contribute towards analysing risk, reliability and loss prevention in process environments.

The content of the first three Outcomes are individual factors that contribute to the whole. The final outcome brings together the previous three in a holistic manner and applies the learning of the previous three to an assignment.

The first three Outcomes may be assessed by one paper or individual papers at the end of each outcome. The final Outcome will be assessed by means of an assignment where the candidate will be required to produce a short written report of at least 500 words.

Details on approaches to assessment are given under Evidence Requirements and Assessment Guidelines under each Outcome in the SQA Advanced Unit specification: Statement of Standards section. It is recommended that these sections be read carefully before proceeding with assessment of candidates.

#### *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.

### 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](http://www.sqa.org.uk/assessmentarrangements).

## **SQA Advanced Unit Specification**

### **General information for candidates**

This Unit has been designed to allow you to develop knowledge and understanding and skills associated Risk Analysis/Reliability and Loss Prevention in Measurement and Control Engineering.

The early part of the Unit deals with reliability and should provide you with a good knowledge in this subject area. You should be able to explain the meaning of reliability and how to improve reliability of measurement and control systems.

The next area that is looked at is maintainability as applied to measurement and control systems, this involves different types of maintenance systems and how they can improve the reliability of the control systems.

Latent fault and trip systems are then explained and the theory behind them.

In the last part of the Unit you will put the skills you have learned to the test by completing an assignment relating to risk analysis, reliability for a measurement and control system.

The formal assessment for this Unit will consist of a written assessment. Outcome 1, 2 and 3 will be a written assessment paper that will last for two hours. This assessment will take place under controlled, supervised conditions in which you will not be allowed to take notes, handouts, textbooks, etc into the assessment.

Outcome 4 will be an assignment in which you will be given a simple control system on which to carry out a Risk Analysis/Reliability study.

The written assessments and assignment will normally be carried out at the end of the delivery of the Unit.