

## SQA Advanced Unit Specification

### General information for centres

**Unit title:** Process Operations: Distillation

**Unit code:** HV9G 48

**Unit purpose:** This Unit is designed to provide candidates with an understanding of the process of distillation. It provides underpinning knowledge and skills needed to give preliminary distillation design data.

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

- 1 Analyse the performance of Distillation and Absorption equipment.
- 2 Perform one 'simple' distillation and one 'plate' distillation.

**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, though it is recommended that candidates have some prior skills in mathematics at SCQF level 6.

**Core Skills:** There are opportunities to develop the Core Skill of *Numeracy* and the components Critical Thinking and Written Communication all at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components. Additionally, *Working with Others* may be developed at SCQF level 5.

**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:** Outcome 1 should be assessed using a supervised assessment. Outcome 2 should be assessed by means of a laboratory report and pro forma based report on practical activities related to the topics in Outcome 1.

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### Unit specification: statement of standards

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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 the Performance of Distillation and Absorption equipment

#### Knowledge and/or Skills

- ◆ Vapour-liquid equilibrium data
- ◆ Minimum number of theoretical stages,  $n_m$ .
- ◆ Minimum reflux ratio,  $R_m$ .
- ◆ Theoretical plates
- ◆ Actual plates (using plate efficiency)
- ◆ Azeotropic and extractive distillations
- ◆ Gas absorption
- ◆ Gas transfer units

#### Evidence Requirements

Evidence for this Outcome will be provided on a sample basis with candidates being required to provide evidence for five of the eight Knowledge and/or Skills items. Assessment must be carried out under supervised conditions.

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- ◆ Calculate vapour-liquid equilibrium data. Calculations must include partial pressure, vapour pressure, relative volatility and reflux ratio.
- ◆ Determine, using both graphical (McCabe-Thiele) and calculation methods, the minimum number of theoretical stages (graphical and Fenske) and minimum reflux ratio (graphical and Underwood).
- ◆ Determine both 'theoretical' (graphical and Gilliland) and 'actual' stage (plate) requirements for a given process.
- ◆ Describe azeotropic and extractive distillations.
- ◆ Determine the number of stages and height of packing in gas absorption column.
- ◆ Determine the number of overall gas transfer units.

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Where calculations are performed, the candidate must:

- ◆ Apply appropriate formulae.  
Apply the principles of the calculation.
- ◆ Show all working through a calculation.
- ◆ Provide reasonable answers to the questions asked. The answer should derive from the application of the formulae and correct application of the principles of the calculation.

### Assessment Guidelines

The assessment for Outcome 1 could be composed of an appropriate balance of short answer, restricted response and structured questions.

## Outcome 2

Perform one 'simple' distillation and one 'plate distillation'

### Knowledge and/or Skills

- ◆ Valves and switches
- ◆ Methods of liquid sample analysis
- ◆ Health and safety regulations
- ◆ Distillation equipment
- ◆ Experimental error and estimate errors

### Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- ◆ Operate valves and switches correctly.
- ◆ Work in a safe manner in accordance with current health and safety regulations.
- ◆ Take liquid samples for further analysis.
- ◆ Analyse liquid samples for chemical composition.
- ◆ Produce a laboratory report for a plate distillation experiment and complete a pro forma report on the simple distillation experiment. The laboratory report should include all results, calculations, experimental and estimate error, and conclusions.

### Assessment Guidelines

Outcome 2 could be assessed by satisfactory completion of two laboratories. The completion of one pro forma for the simple distillation experiment and one laboratory report for the plate distillation experiment is required. An observational checklist for safe working practice could be used.

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### Administrative information

**Unit code:** HV9G 48

**Unit title:** Process Operations: Distillation

**Superclass category:** YC

**Original date of publication:** November 2017

**Version:** 01

### History of changes:

Version	Description of change	Date

**Source:** SQA

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## **SQA Advanced Unit Specification**

### **Unit specification: support notes**

#### **Unit title:** Process Operations: Distillation

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 aim is to give candidates the underpinning theoretical and practical knowledge of the principles of distillation.

##### **Outcome 1**

Candidates should be able to calculate relative volatilities and use this information to determine equilibrium vapour-liquid data.

Candidates should be able to determine the minimum number of theoretical stages using both the graphical method of McCabe-Thiele and the Fenske equation.

Candidates should be able to determine the minimum reflux ratio both graphically and by using the Underwood equation or alternative.

After working out the operating reflux ratio, candidates should be able to determine the number of theoretical plates by both graphical method and by the use of the Gilliland correlation.

From overall plate efficiency data candidates should now be able to determine the number of actual plates in a column.

Candidates should also be able to demonstrate an understanding of other types of distillation processes such as azeotropic and extractive distillations.

Candidates should be able to calculate the number of theoretical and actual stages in a gas absorption Unit, they should also be able to calculate the height of packing within the Unit. It is also expected that candidates should be able to calculate the number of gas transfer units

##### **Outcome 2**

Candidates perform two experiments involving distillation. One is a 'simple distillation' of a methanol-water mixture which is partially separated. Candidates adjust cooling water and steam supply valves at the start of the experiment and take samples for analysis by measurement of relative density using a hydrometer.

The other experiment is a 'plate distillation' where the candidates work with an eight plate distillation tower, taking readings of plate temperatures and samples from both top and bottom plates. By using a reflux divider a sample of overhead product can be obtained for analysis. The performance of the tower can, thus be examined.

Reference is made at all times to HASAWA and COSHH assessments.

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

This Unit is designed to form part of a Group Award in SQA Advanced Certificate/SQA Advanced Diploma in Chemical Process Technology and SQA Advanced Certificate in Chemical Engineering. The Unit requires the candidate to be familiar with the main concepts of distillation.

Independent study should be encouraged by using candidate centred learning material although it is envisaged that candidates will require a significant amount of planned instruction.

The assessment for Outcome 1 can be a single, combined open/closed-book end of Unit test under supervised conditions and should be completed in about 90 minutes. The first section could be a series of calculations using both graphical and numerical methods while the second section could be descriptive.

The assessment for Outcome 2 tests the candidate's ability to perform practical work relating to the distillation theory. Ideally, work could be done individually but limited resources are likely to necessitate the experiments being done in groups of two.

The laboratory reports produced by each candidate should be clear and concise with all results and calculations (where necessary) reported. Candidates should discuss briefly any sources of error. The 'simple distillation' experiment can be done at any time during the delivery of the Unit while the 'plate distillation' experiment could be attempted towards the end of the Unit owing to its more complex nature.

#### A note on the Evidence Requirements

The Evidence Requirements state that candidates 'must provide a satisfactory response' which includes reasonable answers derived 'from the application of the formula and correct application of the principles of the calculation'. This allows for acknowledgement of the correct working and application of formulae, even where candidates' final answer may be inaccurate.

The statement allows for the eventuality where a single error at one stage in an extended calculation sequence has a cumulative effect on the final answer, even though working/formulae are otherwise correctly applied. Acknowledgement of the correct working should be given in such cases.

#### *Opportunities for developing Core Skills*

There are opportunities to develop the Core Skill of *Numeracy* and the components Critical Thinking and Written Communication all at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components. Additionally, *Working with Others* may be developed at SCQF level 5.

Throughout this Unit candidates are required to perform calculations, manage formulae and use equations, providing the opportunity to develop Numeracy skills. In Outcome 1 candidates will also be required to interpret and plot graphs.

Candidates may also be required to use and interpret graphs and in Outcome 2 candidates that also contribute to the development of the Core Skills of *Numeracy*.

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The presentation of problems in assessments that require candidates to interpret and work through the problem set will also develop Critical Thinking in the Core Skills of *Problem Solving* at SCQF level 6. The laboratory component in Outcome 2 also provides the opportunity to develop Critical Thinking skills, and the written component of the Core Skill *Communication*.

Where candidates require to conduct experiments in partnerships or teams there may be opportunities to develop the Core Skill of *Working with Others* at SCQF level 5.

### **Open learning**

If this Unit is delivered by open or distance learning methods, additional planning resources may be required for candidate support, assessment and quality assurance.

### **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: Process Operations: Distillation

This is a single credit Unit at SCQF level 7, intended for candidates undertaking a Chemical Engineering SQA Advanced Certificate or Chemical Process Technology SQA Advanced Certificate/SQA Advanced Diploma. It is designed to provide you with an introduction to some of the main concepts of the diffusional process of distillation.

On completion of this Unit you should be able to:

- 1 Analyse the performance of Distillation and Absorption equipment.
- 2 Perform one 'simple' distillation and one 'plate' distillation.

In Outcome 1 you will be able to analyse the performance of Distillation and Absorption equipment through being able to:

- ◆ calculate vapour-liquid equilibrium data from vapour pressures and relative volatility data
- ◆ determine the minimum number of theoretical stages for a distillation column both graphically and by calculation
- ◆ determine the minimum reflux ratio both graphically and by calculation
- ◆ determine the number of theoretical stages for a given operating system (both graphically and by calculation)
- ◆ determine the number of actual stages using the concept of plate efficiency
- ◆ describe additional distillation processes
- ◆ carry out calculations based on gas absorption units

This Outcome may be assessed by a single end of Unit assessment which will test your knowledge and understanding of the topics listed. This will be conducted under closed-book conditions and will need to revise all the subjects covered even though not all of the subjects may be in the assessment.

#### Outcome 2

Perform one 'simple' distillation and one 'plate' distillation.

In this Outcome you will carry out experiments on a 'simple' distillation apparatus and a batch 'plate' distillation apparatus where you will have to take liquid samples and analyse them by different methods, take readings and operate valves and switches correctly.

This Outcome will be assessed by the production of a full laboratory report for the plate distillation and a pro forma report for the simple distillation.

You will also have the opportunity to develop Core Skills in *Numeracy*, *Problem Solving* and *Communication* at SCQF level 6. Throughout the Unit you will perform calculations, manage formulae and use equations, developing Numeracy skills. You will also be required to interpret and plot graphs.

The practical focus of the Unit will require you to interpret and work through set problems that will develop Critical Thinking skills. The laboratory component in Outcome 2 also provides the opportunity to develop Written Communication skills and the Core Skill *Working with Others*.