

SQA Advanced Unit specification

General information

Unit title: Process Operations: Distillation (SCQF level 8)

Unit code: HV06 48

Superclass: YC

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Version: 01

Unit purpose:

This Unit is suitable for learners studying at SQA Advanced Diploma level. This Unit is designed to provide learners with an understanding of the process of distillation. It provides underpinning knowledge and skills needed to give preliminary distillation design data at SQA Advanced Diploma level or for those seeking employment in a biotechnology and/or chemical based industry.

Outcomes

On successful completion of the Unit the learner will be able to:

- 1 Analyse the performance of distillation equipment.
- 2 Perform one simple distillation and one plate distillation experiment.

Credit points and level

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

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Recommended entry to the Unit

Entry to this Unit is at the discretion of the centre; however it is recommended that learners should have experience of Chemical Engineering at SCQF level 7. Where the Unit is delivered as part of an SQA Advanced Group Award, it is anticipated that learners will have completed level 7 Units in Chemical Engineering principles. Prior to commencing this Unit it is recommended that learners have some prior skills in Mathematics SCQF level 5, Chemical Engineering Principles or Applied Physical Chemistry at SCQF level 7

Core Skills

Achievement of this Unit gives automatic certification of the following Core Skills component:

Complete Core Skill	None
Core Skill component	Using Number at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

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.

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.

SQA Advanced Unit specification: Statement of standards

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Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Outcome 1

Analyse the performance of distillation equipment.

Knowledge and/or Skills

- ◆ Theory of fractional distillation
- ◆ 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

Outcome 2

Perform one simple distillation and one plate distillation experiment.

Knowledge and/or Skills

- ◆ Standard operating procedures (SOP)
- ◆ Current health and safety requirements
- ◆ Distillation and plate distillation equipment
- ◆ Distillation methodology
- ◆ Experimental And estimated errors
- ◆ Recording observations and results
- ◆ Evaluation skills
- ◆ Result analysis and conclusions

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcome 1 should be assessed under supervised closed-book conditions. It is recommended that the assessment be completed within two hours. Learners may have access to a data sheet/relevant equations during the assessment

Written and/or oral recorded evidence for Outcome 2 should be assessed by the production of a full laboratory report and the completion of a pro forma style report on using distillation apparatus. An assessor's observation checklist should be used to record performance evidence of the practical experiments which should be carried out under current health and safety regulations

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Outcome 1

The assessment will cover all of the Knowledge and/or Skills items.

A learner's response will be judged satisfactory where the evidence shows that the learner can:

- ◆ describe types of distillation and equipment.
- ◆ calculate vapour-liquid equilibrium data. Calculations must include partial pressure, vapour pressure, relative volatility and reflux ratio.
- ◆ determine, using 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.

Where calculations are performed, the learner 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.

Outcome 2

Learners will perform two experiments one simple distillation and one plate distillation. A learner's response will be judged satisfactory where the evidence shows that the learner can achieve all of the following:

- ◆ Be able to follow standard operating procedures (SOP).
- ◆ Work in a safe manner in accordance with current health and safety regulations.
- ◆ Use SOPs to facilitate use of simple distillation and plate distillation equipment.
- ◆ Use distillation equipment to separate a binary mixture by two different distillation methods (simple and plate).
- ◆ Use knowledge of distillation methodology to take liquid samples for further analysis.
- ◆ Make reference to experimental errors, estimating errors where appropriate.
- ◆ Evaluate the samples using knowledge of distillation methodologies.
- ◆ Analyse the results obtained and make appropriate conclusions.

The knowledge and skills from Outcome 1 will be used to facilitate Outcome 2 which should be assessed by satisfactory completion of two practical reports based on the theories studied in Outcome 1.

The Laboratory reports should include all results, calculations, experimental data and estimation of error and conclusions. One pro forma for the simple distillation experiment and one laboratory report for the plate distillation experiment. This could be done individually or in small groups.

An assessor observational checklist will be used to record the learner's performance of the practical work in line with given instructions and health and safety requirements.

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Learners will 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 errors, and conclusions.

Where a learner does not perform an assessed practical experiment to the required standard, they will be given the chance to either reattempt the same practical experiment, or to undertake a different practical experiment of similar complexity. Where a report or pro forma does not meet required standard, then the learner will be given a single opportunity to re-draft. If the required standard is still not attained, then an alternative practical experiment will be set.

SQA Advanced Unit Support Notes

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Unit Support Notes are offered as guidance and 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 may form part of a group award or may be completed as a free-standing unit. The Unit requires the learner to be familiar with the main concepts of distillation

It is designed to develop the practical scientific skills involved in Process Operations Distillation and to enable progression to further study or to support the study of such skills in the workplace.

Outcome 1

Demonstrate an understanding of other types of distillation processes such as azeotropic and extractive distillations.

Calculate relative volatilities and use this information to determine equilibrium vapour-liquid data.

Determine the minimum number of theoretical stages using both the graphical method of McCabe-Thiele and the Fenske equation.

Determine the minimum reflux ratio both graphically and by using the Underwood equation or alternative.

Work out the operating reflux ratio; determine the number of theoretical plates by both graphical method and by the use of the Gilliland correlation.

From overall plate efficiency data determine the number of actual plates in a column.

Outcome 2

Perform two experiments involving distillation. One is a 'simple distillation' of a methanol-water mixture, which is partially separated.

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' work with a 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.

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In carrying out such activities, learners should follow good laboratory practice, be able to follow standard operating procedures and be familiar with the Risk and COSHH assessments on all procedures taken.

Opportunities should be taken to develop awareness of sources of experimental errors and accuracy of measurements with quantification of errors where possible.

Guidance on approaches to delivery of this Unit

It is envisaged that the content of this Unit could be delivered stand-alone, or embedded within other Units of an SQA Advanced Award.

It is important that learners are allocated laboratory time to develop competence in underpinning practical techniques prior to assessment.

Learners should be encouraged to develop their awareness of health and safety aspects and Good Laboratory Practice (GLP) throughout the practical activities.

Learners should be supported in developing competence in a broad range of scientific communication techniques such as writing laboratory reports, presentations and posters where appropriate.

Outcome 1

It is envisaged that delivery of Outcome 1 would commence with an introduction to distillation and the theory of distillation then followed by the description of distillation processes (internal and external components).

Introduction to analysis and performance of distillation equipment through being able to:

- ◆ perform calculations involving 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 of the number of theoretical stages for a given operating system (both graphically and by calculation).
- ◆ determine of the number of actual stages using the concept of plate efficiency.
- ◆ describe additional distillation processes.

Outcome 2

It is envisaged that laboratory work and demonstrations involving one 'simple' distillation and one 'plate' distillation practical will feature across the delivery of each of the Outcomes and the assessed practical experiments for Outcome 2 will be undertaken in a similar time frame to the underpinning theory.

In this Outcome students will carry out experiments on a 'simple' distillation apparatus and a batch 'plate' distillation apparatus where they will need to take liquid samples and analyse them by different methods, they will also have to take readings and operate valves and switches correctly. Where possible, it may be appropriate during delivery of this Unit to visit

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an industrial site to demonstrate to learners the use of good practice, risk assessment and COSHH assessments in a work based setting

Guidance on approaches to assessment of this Unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

The assessment for Outcome 1 can be a single, closed-book Unit test under supervised conditions and should be completed within two hours. The first section could be a series of calculations using both graphical and numerical methods while the second section could be a descriptive question about equipment.

The assessment for Outcome 2 tests the learner's ability to perform practical work relating to the distillation theory. Best way of assessing is individually or in small groups.

The laboratory reports produced by each learner should be clear and concise with all results and calculations (where necessary) reported. Learners 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.

Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment, which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres, which wish to use E-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of E-assessment to support SQA's qualifications is available at www.sqa.org.uk/e-assessment.

Opportunities for developing Core and other essential skills

The delivery of this Unit will provide learners with the opportunity 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 learners are required to perform calculations, manage formulae and use equations, providing the opportunity to develop *Numeracy* skills.

In Outcome 1 learners will also be required to interpret and plot graphs.

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

This Unit has the Using Number component of Numeracy embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show they have achieved Using Number at SCQF level 6.

History of changes to Unit

Version	Description of change	Date

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General information for learners

Unit title: Process Operations: Distillation (SCQF level 8)

This is a single credit Unit at SCQF level (8) intended for learners studying at SQA Advanced Diploma level. 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:

- ◆ analyse the performance of distillation equipment.
- ◆ perform one simple distillation and one plate distillation experiment.

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.

Assessment

For Outcome 1 you will take a closed-book, end of Unit assessment.

Outcome 2 will be assessed after you have learned the necessary practical skills and related theory and will take the form of one 'simple' distillation and one 'plate' distillation experiments.

You will carry out experiment 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.

Core Skills

Although there is no automatic certification of Core Skills in this Unit you will have opportunities 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*.