SQA Advanced Unit specification

General information

Unit title: Process Operations: Heat Exchange, Drying and Evaporation (SCQF level 8)

Unit code: HV07 48

Superclass: XH

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Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to provide learners with the knowledge to apply the principles of mass and heat exchange to industrial units. This Unit is suitable for learners studying at SQA Advanced Diploma level, and will provide the necessary underpinning knowledge to enable progression to further study of chemical engineering or to seek employment in the chemical and oil industries.

Outcomes

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

1 Apply the theory of forced convection to heat exchange systems.
2 Apply heat transfer theory with mass and energy balances to evaporation processes.
3 Apply humidification and drying theories to industrial systems.

Credit points and level

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

Recommended entry to the Unit

Entry is at the discretion of the centre, however it is recommended that learners should have completed the SQA Advanced Unit *Heat Transfer Theory and Practical Skills* (HV09 47) or equivalent, or have experience of heat transfer at SCQF level 7.

Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the Support Notes for this Unit specification.

There is no automatic certification of Core Skills or Core Skill components in this Unit.

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

Unit title: Process Operations: Heat Exchange, Drying and Evaporation (SCQF level 8)

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.

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. Learners 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

Apply the theory of forced convection to heat exchange systems.

Knowledge and/or Skills

- Heat transfer theory and dimensionless equations
- Convection, film coefficients and geometries
- Overall heat transfer coefficient
- Heat exchanger sizes

Outcome 2

Apply heat transfer theory with mass and energy balances to evaporation processes.

Knowledge and/or Skills

- Industrial evaporation processes and evaporation problems
- Selection of evaporation plant
- Hazards and safety precautions
- Calculations of heat transfer rates and economy

Outcome 3

Apply humidification and drying theories to industrial systems.

Knowledge and/or Skills

- Humidification and drying terms
- Drying mechanisms, curves and periods
- Drying theory applied to solve numerical problems using psychrometric chart

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1 and 3 could be assessed using a holistic closed-book assessment under supervised conditions. Outcomes may also be assessed individually. The assessment will use a sampling approach to the Knowledge

and/or Skills as detailed below. It is recommended that the assessment be completed within 90 minutes, or 45 minutes if the Outcomes are assessed individually.

Written and/or oral recorded evidence for Outcome 2 could be assessed by a closed-book assessment under supervised conditions. The assessment will use a sampling approach to the Knowledge and/or Skills as detailed below. It is recommended that the assessment be completed within 45 minutes. The research part of Outcome 2 could be assessed by an oral presentation. An assessor's observation checklist could be used to record performance evidence of the oral presentation.

Outcome 1

The assessment will sample three of the four Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- apply dimensionless equations for the appropriate geometries to the calculation of film coefficients of heat transfer. These geometries must include: coils, agitated vessels, flow through tubes, flow in annular gaps.
- apply dimensionless analysis to show Nu = f(Re)(Pr)(Gr).
- calculate the overall heat transfer coefficient based on inside and outside surfaces.
- use appropriate short cut relationships for air and water and apply heat exchange theory to the calculation of required heat exchanger size.

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

The assessment will sample three of the four Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- describe industrial evaporation processes using flow diagrams. The description must include single and multiple effect evaporation, forward, backward and parallel feed systems.
- explain the factors affecting the selection of evaporation plant for industrial processes. The explanation must include capital and energy costs, evaporation duty, time on stream, thermal sensitivity of solutions and crystallisation.
- research the hazards in evaporation processes and the relevant safety precautions required to reduce or remove the hazard.

- apply the principles of evaporation using mass and energy balances when solving evaporation problems. The application must include calculation of heat transfer area of calandria and the calculation of economy.

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 3

The assessment will sample two of the three Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- explain the following terms relevant to humidification and drying: humidity, humid heat, percentage saturation, relative humidity, humid volume, adiabatic saturation temperature, wet and dry bulb temperatures.
- explain drying mechanisms. The explanation must include moisture contents, drying curves, constant rate and first and second drying periods.
- apply drying theory to solve numerical problems. The problems must include the calculation of psychrometric properties from: vapour pressure, ideal gas equation, Raoult's and Dalton's Laws; wet and dry basis moisture contents, equilibrium moisture content, critical moisture content, free moisture content; drying curves — moisture content versus time, drying rate versus moisture content, the identification of constant rate, first and second drying periods; calculations of drying time, flow rate of drying medium, energy consumption.

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.

SQA Advanced Unit Support Notes

Unit title: Process Operations: Heat Exchange, Drying and Evaporation (SCQF level 8)

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 be completed as a free-standing Unit. It is designed to provide learners with the knowledge to apply the principles of mass and heat exchange to industrial units introduced in the SQA Advanced Unit *Heat Transfer Theory and Practical Skills* (HV09 47).

Outcome 1 — Apply the theory of forced convection to heat exchange systems

- Application of dimensional analysis to show Nu = f (Re)(Pr)(Gr)
- Application of dimensionless equations to the following geometries: flow through tubes, flow in annular gaps, coils, agitated vessels
- Short cut relationships for air and water
- Condensing vapours — Nusselt equation
- Allowance for fouling of heat exchange surfaces — fouling resistances
- Calculation of overall heat transfer coefficients, based on inside and outside surfaces
- Logarithmic mean temperature difference
- Calculation of heat transfer areas, length, tube number

Outcome 2 — Apply heat transfer theory with mass and energy balances to evaporation processes

- Single and multiple effect evaporation
- Forward, backward and parallel feed systems
- Applications of mass and energy balances to solve evaporator problems
- Calculation of heat transfer area of calandria
- Calculation of economy
- Boiling point elevation, hydrostatic head effects
- Vapour recompression using steam ejectors and mechanical compression
- Description by means of flow diagrams
- Climbing film evaporators
- Evaporator selection criteria: capital and energy costs, evaporation duty, time on stream, thermal sensitivity of solutions, crystallisation
- Hazards and relevant safety precautions

Outcome 3 — Apply humidification and drying theories to industrial systems

- Explanation of humidification terms: humidity, humid heat, percentage saturation, relative humidity, humid volume, adiabatic saturation temperature, wet and dry bulb temperatures

- Explanation of drying mechanisms, moisture contents, drying curves, constant rate and first and second drying periods.
- Calculation of psychrometric properties including:
  - — Vapour pressure, ideal gas equation, Raoult's and Dalton's Laws
  - — Wet and dry basis moisture contents, equilibrium moisture content, critical moisture content, free moisture content
  - — Drying curves — moisture content versus time, drying rate versus moisture content, the identification of constant rate, first and second drying periods
  - — Calculations of drying time, flow rate of drying medium, energy consumption

Guidance on approaches to delivery of this Unit

Outcomes 1, 2 and 3 could be delivered in any order. It is envisaged that delivery of Outcome 1 could commence with the concept of dimensionless equations for the appropriate geometries to the calculation of film coefficients of heat transfer. These geometries must include: coils, agitated vessels, flow through tubes, and flow in annular gaps. Delivery could then focus on the calculation of the overall heat transfer coefficient based on inside and outside surfaces. The use of appropriate short cut relationships for air and water and the application of heat exchange theory to the calculation of required heat exchanger size could then be covered.

Delivery of Outcome 2 could commence with the description of industrial evaporation processes using flow diagrams. The description must include single and multiple effect evaporation, forward, backward and parallel feed systems as well as the factors affecting the selection of evaporation plant for industrial processes. The factors affecting the selection of evaporation plant for industrial processes could then be explained and the explanation must include capital and energy costs, evaporation duty, time on stream, thermal sensitivity of solutions and crystallisation. Delivery could then focus on investigating the hazards in evaporation processes and the relevant safety precautions required to reduce or remove the hazard. It is envisaged that learners are asked to prepare for the descriptive element of Outcome 2 at this stage. The principles of evaporation using mass and energy balances when solving evaporation problems should also be covered. The application must include calculation of heat transfer area of calandria and the calculation of economy.

Delivery of Outcome 3 could commence with the description of the following terms relevant to humidification and drying: humidity, humid heat, percentage saturation, relative humidity, humid volume, adiabatic saturation temperature, wet and dry bulb temperatures. Drying mechanisms could then be explained to include moisture contents, drying curves, constant rate and first and second drying periods. Finally, the application of drying theory to solve numerical problems could be covered. The problems must include the calculation of psychrometric properties from: vapour pressure, ideal gas equation, Raoult's and Dalton's Laws; wet and dry basis moisture contents, equilibrium moisture content, critical moisture content, free moisture content; drying curves — moisture content versus time, drying rate versus moisture content, the identification of constant rate, first and second drying periods; calculations of drying time, flow rate of drying medium, energy consumption.

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.

Outcomes 1 and 3 could be assessed by a single holistic closed-book assessment with an appropriate cut-off score that covers the sampling requirements as detailed in the Evidence Requirements. Outcomes may also be assessed individually. Assessment should be carried

out in supervised conditions. It is recommended that the assessment be completed within 90 minutes when both Outcomes are assessed together, or 45 minutes when assessed separately. The assessment for Outcomes 1 and 3 could be composed of an appropriate balance of short answer, restricted response and structured questions.

Outcome 2 could be assessed by a closed-book assessment with an appropriate cut-off score that covers the sampling requirements as detailed in the Evidence Requirements. Assessment should be carried out in supervised conditions, and it is recommended that the assessment be completed within 45 minutes. The assessment could be composed of an appropriate balance of short answer, restricted response and structured questions.

Alternatively, the research element of Outcome 2 could be assessed by an oral presentation by asking learners to select a relevant topic in relation to industrial evaporators. The presentation could be presented to a relevant audience, using appropriate visual aids and assessed by an assessor's observation checklist. The presentation could be delivered for a minimum of five minutes, followed by questions. It is envisaged that topics will be allocated within a group to ensure a reasonable sample of the decisive elements is covered by the group. An assessor's observation checklist and/or a video recording and support materials should be retained as evidence of performance for each learner.

The assessor's observation checklist could cover the following:

- Select accurate and relevant data and information, and structure it appropriately for the purpose and audience
- Produce visual aids appropriate for purpose and audience and use the aids effectively in the presentation
- Respond to points of view and/or questions from the audience in an appropriate and knowledgeable manner

Where evidence of Outcomes is assessed by sampling, the whole of the content listed in the Knowledge and/or Skills must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed, and different items should be sampled on each assessment occasion. Any items not sampled in the first assessment, must be included in the alternative (re-sit) assessment.

For all Outcomes, the Evidence Requirements state that learners 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 learners' 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.

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.

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 and assessment of this Unit will provide learners with the opportunity to develop the Core Skills of *Numeracy* and *Problem Solving* at SCQF level 6 and *Information and Communication Technology (ICT)* at SCQF level 4.

***Numeracy* — Using Number at SCQF level 6**

Learners will perform calculations, manage formulae, use equations, interpret and plot graphs and use flow diagrams.

***Problem Solving* — Critical Thinking at SCQF level 6**

The practical focus of the Unit and the research aspect of Outcome 2 will require learners to interpret and work through set problems.

***Information and Communication Technology (ICT)* — Providing/Creating information at SCQF level 4**

Learners could make effective and appropriate use of ICT packages to produce an oral presentation in an appropriate format. Packages used will likely include word processing, PowerPoint, and specialist flow diagram processes software.

History of changes to Unit

Version	Description of change	Date

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

General information for learners

Unit title: Process Operations: Heat Exchange, Drying and Evaporation (SCQF level 8)

This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment.

This is a 1 credit Unit at SCQF level 8, which you may be studying as part of the first year of an SQA Advanced Certificate/Diploma engineering programme or as a freestanding unit. This Unit is designed to provide you with the knowledge to apply the principles of mass and heat exchange to industrial units. Before progressing to this Unit it would be beneficial to have completed the SQA Advanced Unit *Heat Transfer Theory and Practical Skills* (HV09 47).

On completion of the Unit you should be able to:

1 Apply the theory of forced convection to heat exchange systems.
2 Apply heat transfer theory with mass and energy balances to evaporation processes.
3 Apply humidification and drying theories to industrial systems.

Outcome 1

You will learn how to develop equations in order to use dimensionless equations. This is an important area in the design and understanding of heat exchange systems. You will use these equations to work out film coefficients for different types of heat exchangers. Finally you will calculate the size of a heat exchanger.

Outcome 2

You will learn about industrial evaporators and the factors affecting the choice of evaporation systems. You will learn about the safety hazards and safety precautions involved in carrying out an evaporation process. You will learn to solve problems related to evaporation by using knowledge about the process.

Outcome 3

You will learn the correct terms related to humidification. You will also learn how to read psychrometric charts and use the data in calculations. You will learn how to calculate the drying time of materials in selected industrial settings.

Assessment

For Outcomes 1 and 3, depending on which centre you attend, assessment may be conducted on an Outcome by Outcome basis or by one single assessment. Assessment will be conducted under closed-book, supervised conditions.

For Outcome 2, depending on which centre you attend, you could take a closed-book assessment conducted under supervised conditions or you could take a closed-book assessment conducted under supervised conditions and deliver an oral presentation.

Core Skills

Although there is no automatic certification of Core Skills in the Unit, you will have opportunities to develop the Core Skills of *Numeracy* and *Problem Solving* at SCQF level 6 and *Information and Communication Technology (ICT)* at SCQF level 4.