



Higher National Unit specification

General information for centres

Unit title: Process Operations: Heat Exchange, Drying and Evaporation

Unit code: F3XG 35

Unit purpose: This Unit is designed to provide candidates with the knowledge to be able to apply the principles of mass and heat exchange to industrial units.

On completion of the Unit the candidate 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.

Credit points and level: 1 HN 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 Access 1 to Doctorates.*

Recommended prior knowledge and skills: Access to this Unit is at the discretion of the centre, but it is preferable for candidates to be able to demonstrate a knowledge of heat transfer at SCQF level 7. Where the Unit is delivered as part of an HN award it is recommended that candidates will have completed HN Unit *Heat Transfer: Theory and Practice* prior to commencing this Unit.

Core Skills: There are opportunities to develop the Core Skill of *Numeracy* and the components Critical Thinking and Oral 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: Candidates could be assessed on an Outcome by Outcome basis. The assessment papers for Outcome 1 and 3 could be composed of an appropriate balance of short answer, restricted response and structured questions. Assessment for Outcome 2 could consist of an oral presentation and an assessment paper composed of an appropriate balance of restricted response and structured questions. Assessment should be carried out under supervised, controlled conditions.

Higher National Unit specification: statement of standards

Unit title: Process Operations: Heat Exchange, Drying and Evaporation

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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

Apply the theory of forced convection to heat exchange systems

Knowledge and/or Skills

- ◆ Forced Convection
- ◆ Dimensionless equations
- ◆ Film coefficients and geometries
- ◆ Heat exchange calculation
- ◆ Heat exchange theory
- ◆ Heat exchangers sizes

Evidence Requirements

Evidence for this Outcome will be provided on a sample basis with candidates being required to provide evidence for four of the six 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:

- ◆ 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

Higher National Unit specification: statement of standards (cont)

Unit title: Process Operations: Heat Exchange, Drying and Evaporation

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 designed to meet the sampling and Evidence Requirements for this Outcome. Assessment should be carried out under supervised conditions.

Outcome 2

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

Knowledge and/or Skills

- ◆ Industrial evaporation processes
- ◆ Selection of evaporation plant
- ◆ Hazards
- ◆ Evaporation problems
- ◆ Calculations of economy
- ◆ Calculation of heat transfer
- ◆ Mass and energy balances
- ◆ Safety precautions

Evidence Requirements

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

The descriptive elements will be assessed by a report on the candidate's research findings.

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

Higher National Unit specification: statement of standards (cont)

Unit title: Process Operations: Heat Exchange, Drying and Evaporation

- ◆ 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 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 2 could be composed of an appropriate balance of short answer, restricted response and structured questions, to cover the calculation and safety element of the Outcome, it is recommended that these be carried out under supervised conditions.

It is envisaged that the research element of this Outcome could be assessed by asking candidates to select a relevant topic in relation to industrial evaporators for delivery as a presentation. The presentation could be presented to a relevant audience, using appropriate visual aids and assessed by using an appropriate checklist.

Outcome 3

Apply humidification and drying theories to industrial systems

Knowledge and/or Skills

- ◆ Humidification and drying terms
- ◆ Drying mechanisms
- ◆ Drying theory applied to solve numerical problems
- ◆ Psychometric properties
- ◆ Raoult's Law
- ◆ Dalton's Law
- ◆ Moisture Content
- ◆ Drying Curves
- ◆ Drying periods

Evidence Requirements

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

Higher National Unit specification: statement of standards (cont)

Unit title: Process Operations: Heat Exchange, Drying and Evaporation

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

- ◆ explain the following terms relevant to humidification and drying; humidity, humid heat, percentage saturation, relative humidity, adiabatic saturation temperatures, 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 psychometric 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, 1st and 2nd drying periods; and calculations of drying time, flowrate of drying medium, energy consumption.

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 3 could be composed of an appropriate balance of short answer, restricted response and structured questions.

Administrative Information

Unit code: F3XG 35

Unit title: Process Operations: Heat Exchange, Drying and Evaporation

Superclass category: XH

Original date of publication: August 2008

Version: 01

History of changes:

Version	Description of change	Date

Source: SQA

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Higher National Unit specification: support notes

Unit title: Process Operations: Heat Exchange, Drying and Evaporation

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 is intended to be part of the HNC Chemical Engineering and HND Chemical Process Technology.

The following areas could be covered when delivering this Unit:

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, 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 selected 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

Higher National Unit specification: support notes (cont)

Unit title: Process Operations: Heat Exchange, Drying and Evaporation

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
- ◆ Calculation of psychometric 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
- ◆ Identification of constant rate, 1st and 2nd drying periods
- ◆ Calculations of drying time, flowrate of drying medium, energy consumption

Guidance on the delivery and assessment of this Unit

This Unit is designed to form part of HND Chemical Process Technology and HNC Chemical Engineering. The Unit requires the candidate to be familiar with the main concepts of heat transfer.

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

The assessments for Outcomes 1, 2 and 3 could be taken by the candidates at the completion of each Outcome. These assessments should be taken under supervised conditions.

It is envisaged that the research element of Outcome 2 could be assessed by asking candidates to select a relevant topic in relation to industrial evaporators for delivery as a presentation. The presentation could be presented to a relevant audience, using appropriate visual aids and assessed by an appropriate 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. A detailed observation checklist and/or a video recording, and support materials should be retained as evidence of performance for each candidate

The 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

It is envisaged that if centres choose to ask candidates to the presentation, part of Outcome 2, will be delivered at an appropriate time during delivery of the Unit.

Higher National Unit specification: support notes (cont)

Unit title: Process Operations: Heat Exchange, Drying and Evaporation

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 Oral 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 the Unit candidates will perform calculations, manage formulae and use equations that develop *Numeracy* skills. They will also be required to interpret and plot graphs and in Outcome 2, use flow diagrams, again contributing to the development of *Numeracy*.

The practical focus of the Unit will require candidates to interpret and work through set problems that will also develop the Critical Thinking component of the *Problem Solving* Core Skill, as will the research aspect of Outcome 2.

Should candidates present findings for the research aspect in Outcome 2 orally, this will provide the opportunity to develop the Oral Communication component at SCQF level 6.

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.

A combination of new and traditional authentication tools may have to be devised for assessment and re-assessment purposes.

For part Outcome 2 candidates must be directly observed and assessed. This could be achieved by arranging a group meeting, by video conferencing or by the candidate producing a video of performance which meets all assessment criteria

Candidates with disabilities and/or additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering alternative Outcomes for Units. Further advice can be found in the SQA document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs* (www.sqa.org.uk).

General information for candidates

Unit title: Process Operations: Heat Exchange, Drying and Evaporation

This is a single credit HN Unit at SCQF level 8 intended for candidates undertaking an HNC in Chemical Engineering and HND Chemical Process Technology. The Unit develops ideas introduced in Heat Transfer theory and Practice and applies them to industrial systems.

In Outcome 1 you will learn how to:

- ◆ develop equations from *Heat transfer Theory and Practice* 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.

In Outcome 2 you will learn about:

- ◆ industrial evaporators, 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 the knowledge about the process. As part of the Outcome you will deliver a short presentation on a relevant evaporation topic.

In Outcome 3 you will learn:

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

For this Unit you will be assessed on an Outcome by Outcome basis. The assessment papers for Outcome 1 and 3 will be composed of an appropriate balance of short answer, restricted response and structured questions. Assessment for Outcome 2 will consist of a presentation and an assessment paper composed of an appropriate balance of restricted response and structured questions. Assessment will be carried out under supervised, controlled conditions.

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 that develop Numeracy skills. You will also be required to interpret and plot graphs and in Outcome 2, use flow diagrams, again contributing to the development of *Numeracy*.

The practical focus of the Unit will require you to interpret and work through set problems that will also develop the Critical Thinking component of the *Problem Solving* Core Skill, as will the research aspect of Outcome 2.

Should you present your findings for the research component in Outcome 2 as an oral presentation this will provide you with the opportunity to develop the Oral Communication component at SCQF level 6.