Higher National Unit specification

General information for centres

Unit title: Heat Transfer: Theory and Practice

Unit code: F3XC 34

Unit purpose: This Unit is designed to provide candidates with a practical introduction to, and understanding of the theory and practice of Heat Transfer. On completion of the Unit, the candidate should be able to:

1 Apply the principles of heat transfer individually to conduction, convection and radiation.
2 Apply the principles of heat transfer to the combined mechanisms of conduction, convection and radiation.
3 Perform practical experiments using heat transfer equipment.

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

Recommended prior knowledge and skills: Access to this Unit will be at the discretion of the centre. It is recommended that candidates have some prior skills in mathematics at SCQF level 6, or equivalent.

Core Skills: There are opportunities to develop the Core Skills of *Numeracy* and *Working with Others*, and the Core Skills 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.

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 and Outcome 2 could be assessed together using a supervised assessment at an appropriate time once Outcomes 1 and 2 have been completed. Outcome 3 should be assessed by means of a laboratory report and pro forma based report on practical activities related to the topics in Outcome 1 and 2.

Higher National Unit specification: statement of standards

Unit title: Heat Transfer: Theory and Practice

Unit code: F3XC 34

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 principles of heat transfer individually to conduction, convection and radiation

Knowledge and/or Skills

- Basic heat transfer mechanisms
- Thermal conductivity, thermal resistance
- Fourier equation
- Heat Transfer.
- Black body radiation, emissivity
- Stefan-Boltzmann Law

Evidence Requirements

Evidence for this Outcome will be provided on a sample basis with candidates being required to provide evidence for two 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:

- describe the terms used in basic heat transfer. The description must include conduction, natural convection, forced convection and radiation
- define the terms thermal conductivity and thermal resistance
- apply the Fourier equation to solve problems involving single and composite plane walls, thick walled and composite cylinders and hollow spheres
- calculate heat transfer loads, film and heat transfer coefficients, fouling factors, log mean temperature differences, natural convection from a surface to air and heat transfer area.
- define black body radiation and emissivity
- apply the Stefan Boltzmann law to solve radiation problems

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

It is recommended a single assessment event is conducted for Outcomes 1 and 2. The assessment could be composed of an appropriate balance of short answer, restricted response and structured questions.

Outcome 2

Apply the principles of heat transfer to the combined mechanisms of conduction, convection and radiation

Knowledge and/or Skills

- Steady state heat transfer
- Surface temperature by graph
- Heat loss to surroundings
- Interface temperatures

Evidence Requirements

Evidence for this Outcome will be provided on a sample basis with candidates being required to provide evidence for three of the four 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 the Fourier equation, natural convection equation and Stefan Boltzmann equation to a simultaneous conduction, convection and radiation problem
- determine graphically the surface temperature of a pipe or wall
- perform at least one calculation for heat loss rate to the surroundings
- perform at least one calculation for interface temperatures

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

It is recommended a single assessment event is conducted for Outcomes 1 and 2. The assessment could be composed of an appropriate balance of short answer, restricted response and structured questions.

Outcome 3

Perform practical experiments using heat transfer equipment

Knowledge and/or Skills

- Heat exchangers
- Health and safety regulations
- Operate appropriate heat exchange equipment
- Experimental error and estimate errors as appropriate

Evidence Requirements

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

- operate steam valves correctly.
- adjust fan control settings correctly.
- read manometer differential pressures.
- read temperatures using thermistor units.
- adjust water flow control valve correctly.
- operate water booster pump correctly.
- operate two different types of heat exchanger in accordance with current health and safety requirements and following instructions.
- perform at least two experiments and produce a laboratory for at least one experiment and a pro-forma report completed for one experiment. The laboratory report must include the results of the experiment, calculations and conclusions drawn. Sources of experimental and estimate errors must be included.

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

Outcome 3 could be assessed by satisfactory completion of one pro forma and one laboratory report.

Administrative Information

Unit code: F3XC 34

Unit title: Heat Transfer: Theory and Practice

Superclass category: RC

Original date of publication: August 2008

Version: 01

History of changes:

Version	Description of change	Date

Source: SQA

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of Higher National qualifications.

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre for further details, telephone 0845 279 1000.

Higher National Unit specification: support notes

Unit title: Heat Transfer: Theory and Practice

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 designed to form part of HNC/HND Chemical Process Technology and HNC Chemical Engineering. The aim is to give candidates the underpinning theoretical and practical knowledge for an understanding of the principles of heat transfer.

Outcome 1

Candidates could describe, using industrial examples, the basic heat transfer mechanisms of conduction, natural and forced convection and radiation.

Candidates could give a more scientific description of the term ‘thermal conductivity’ particularly with regard to heat transfer rate, area and temperature gradient. Candidates should be able to solve problems using the Fourier equation particularly with respect to plane walls, composite walls, cylindrical (lagged) pipes and Hortonspheres.

Candidates could calculate heat transfer loads, log mean temperature differences, film and overall heat transfer coefficients. Using these values, heat transfer areas can be determined and hence ‘number of tubes’ for heat exchangers evaluated.

Candidates could define’ black body radiation’ and ‘emissivity’ and apply the Stefan Boltzmann equation to solve radiation problems.

Outcome 2

Candidates could apply acquired knowledge to solve a more complex problem involving simultaneous conduction, natural convection and radiation. Numerical data can be provided to allow the candidate to determine, graphically, the surface temperature of a pipe or wall. This temperature value will now permit calculation of both heat loss rate to the surroundings and interface temperatures.

Outcome 3

This Outcome is the practical element of the Unit where candidates will follow both verbal and written instructions to perform experiments on heat exchangers.

Candidates are expected to work safely in accordance with current health and safety regulations.

Candidates should obtain accurate results and report these clearly in a full laboratory report and completed pro forma report.

Higher National Unit specification: support notes (cont)

Unit title: Heat Transfer: Theory and Practice

Guidance on the delivery and assessment of this Unit

Whilst this could be delivered as a stand-alone Unit, it has been designed as part of the HNC/HND Chemical Process Technology and HNC Chemical Engineering. The Unit requires the candidate to be familiar with the fundamental 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 assessment for Outcomes 1 and 2 is recommended as a single holistic assessment.

The assessment for Outcome 3 involves the practical aspect of the Unit. Practical work could include two different heat exchangers, for example a 'concentric tube exchanger' and a 'plate heat exchanger' or a 'spiral heat exchanger'. The candidate could apply much of the theory learned in the previous Outcomes to practical situations.

A note on the Evidence Requirements

The Evidence Requirements state that candidates must 'provide reasonable answers' derived 'from the application of the formulae 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 *Working with Others*, and the component Critical Thinking of the Core Skill of *Problem Solving* at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Throughout this Unit candidates are required to perform calculations, manage formulae and equations that provide the opportunity to develop the Core Skill of *Numeracy* at SCQF level 6. In Outcome 2 candidates will also be required to interpret and plot graphs which again provides the opportunity to develop *Numeracy* skills.

The presentation of problems in assessments which candidates require to interpret and work through will also develop the Critical Thinking component of *Problem Solving*, at SCQF level 6.

The production of the laboratory report and pro forma based report on practical activities provides opportunities to develop the component Written Communication of the Core Skill of *Communication*.

Candidates working in labs may develop the Core Skill of *Working with Others*, if working with lab partners.

Higher National Unit specification: support notes (cont)

Unit title: Heat Transfer: Theory and Practice

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.

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: Heat Transfer: Theory and Practice

Whilst this Unit may be studied on a standalone basis, it has been designed as a single-credit HN Unit at SCQF level 7 intended for candidates undertaking an HNC/HND Chemical Process Technology or HNC Chemical Engineering. It is designed to provide you with knowledge of some of the main concepts of the theory and practice of *Heat Transfer*. Whilst access to the Unit is at the discretion of the centre it would be beneficial if you had studied mathematics at SCQF level 6.

On completion of this Unit you should be able to:

- describe the terms conduction, convection, radiation, thermal conductivity, emissivity and black body radiation
- apply the Fourier equation for conduction to walls, pipes and spheres
- use heat transfer coefficients and log mean temperature differences to determine heat transfer surface requirements
- apply the Stefan-Boltzmann equation for radiation heat transfer between surfaces
- apply the combined mechanisms of conduction, convection and radiation to heat transfer applications
- perform experiments on heat exchangers to determine heat transfer data

Outcomes 1 and 2 may be assessed together using a single, supervised assessment. Outcome 3 will be assessed by means of a laboratory report and pro forma based report on practical activities related to the topics in Outcome 1 and 2.

Throughout the Unit you will also have the opportunity to develop Core Skills in *Numeracy*, and *Problem Solving* at SCQF level 6. You will perform calculations, manage formulae and equations that may develop the Core Skill of *Numeracy* at SCQF level 6. You will also be required to interpret and plot graphs, which again provides the opportunity to develop the Core Skill of *Numeracy*.

The practical focus of the Unit will require you to interpret and work through set problems which will develop critical thinking skills. The laboratory component in Outcome 2 may also provide the opportunity to develop Critical Thinking skills, ensuring development of the Critical Thinking component of the Core Skill of *Problem Solving*, at SCQF level 6. Candidates working in labs may develop the Core Skill of *Working with Others*, if working with lab partners.

The production of the laboratory report and pro forma based report on practical activities provides opportunities to develop the component Written Communication of the Core Skill of *Communication*.