Higher National Unit specification: general information

Unit title: Building Services Engineering Science

Unit code: FT95 34

Superclass: TH

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Source: Scottish Qualifications Authority

Version: 01

Unit purpose

The aim of this Unit is to develop candidate understanding of principles and concepts used in a wide range of building services applications and to provide a basis from which the more specialised service applications can be developed.

The Unit explores core fundamental principles and formulae of fluid flow, heat transfer, acoustics, electrical energy performance and controls systems.

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

- identify human and environmental factors influencing thermal comfort
- analyse and apply basic principles to the flow of heat energy and fluids
- evaluate how the electrical energy performance of buildings can be improved
- investigate the characteristics, transmission and effects of sound and vibration
- identify elements of control systems and their performance

Recommended prior knowledge and skills

It would be an advantage for candidates to have a basic understanding and knowledge of building services engineering science and technology.

Such understanding and knowledge may be evidenced by the possession of a National Certificate in Building Services Engineering or a related subject.

The Unit includes all the basic principles necessary to allow candidates possessing other qualifications or experience to succeed in this Unit.

General information (cont)

Unit title: Building Services Engineering Science

Credit points and level

1 Higher National Unit 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.*

Core Skills

There may be opportunities to gather evidence towards core skills in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Context for delivery

This Unit was developed for the HNC in Building Services Engineering. 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

It is possible to assess candidates either on an individual Outcome basis, combinations of Outcomes or by a single holistic assessment combining all Outcomes. The assessment paper(s) should be composed of an appropriate balance of short answer, restricted response and structured questions. Assessment should be conducted under supervised, controlled conditions. A single assessment covering all Outcomes should not exceed 2 hours in duration. It should be noted that candidates must achieve all the minimum evidence specified for each Outcome in order to pass this Unit.

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.

An exemplar instrument of assessment and marking guidelines has been produced to provide examples of evidence required to demonstrate achievement of the aims of this Unit.

Higher National Unit specification: statement of standards

Unit title: Building Services Engineering Science

Unit code: FT95 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

Identify human and environmental factors influencing thermal comfort.

Knowledge and/or Skills

- Physiological and psychological factors.

Evidence Requirements

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

- explain the physiological mechanisms which control the energy balance of the human body
- identify and measure the variables of an internal environment which might influence the thermal equilibrium of a human body
- evaluate thermal indices and the reliability of design criteria for maintaining thermal comfort in internal environments
- identify the implications of thermal indices in the design of heating and air conditioning systems

In any assessment of this Outcome **all** knowledge and/or skills items should be included. Candidates must provide a satisfactory response to all items.

Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under open-book conditions.

Assessment Guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment for this Outcome might be combined with that for Outcomes 2, 3, 4 and 5 to form a single assessment paper.

Higher National Unit specification: statement of standards (cont)

Unit title: Building Services Engineering Science

Outcome 2

Analyse and apply basic principles to the flow of heat energy and fluids.

Knowledge and/or Skills

- Heat transfer rates
- Fluid flow
- Reynolds number
- Energy losses

Evidence Requirements

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

Heat flow
- describe the modes of heat transfer
- determine heat energy transfer rates by convection and thermal radiation systems
- determine heat energy transfer rates by conduction through composite, complex and thermally bridged structures
- select insulation thickness for specified or optimum performance
- determine interstitial condensation occurrence in multileaf plane structures

Fluid flow
- apply Bernoulli's equation to express the concept of conservation of energy in a moving fluid
- determine volume/mass transfer using the venturi, orifice plate and pitot static tube
- assess the significance of Reynolds number in pipeline flow
- determine the frictional coefficient in turbulent flow
- determine frictional head losses in pipe and duct networks
- determine static regain in ductwork fittings
- resolve problems in gravitational flow in flooded and partially flooded conduits

In any assessment of this Outcome **three out of four** knowledge and/or skills items should be included. Candidates must provide a satisfactory response to three items.

Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under open-book conditions.

Assessment Guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment for this Outcome might be combined with that for Outcomes 1, 3, 4 and 5 to form a single assessment paper.

Higher National Unit specification: statement of standards (cont)

Unit title: Building Services Engineering Science

Outcome 3

Evaluate how the electrical energy performance of buildings can be improved.

Knowledge and/or Skills

- Electrical lighting loads and energy demands
- Electrical induction loads
- Control of building systems

Evidence Requirements

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

- determine typical electrical lighting loads for a commercial building
- appraise the impact of the choice of lamp and lighting strategy on energy conservation
- determine typical electrical induction loads (single phase)
- evaluate measures that can be employed to reduce energy demand from electrical induction loads
- describe control systems suitable for controlling induction loads (single phase) and explain how this may prove to be economically practical

Assessment Guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment for this Outcome might be combined with that for Outcomes 1, 2, 4 and 5 to form a single assessment paper.

Higher National Unit specification: statement of standards (cont)

Unit title: Building Services Engineering Science

Outcome 4

Investigate the characteristics, transmission and effects of sound and vibration.

Knowledge and/or Skills

- Sound
- Room acoustics
- Vibration

Evidence Requirements

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

- analyse the power/frequency spectra of acoustic sources
- identify external and internal sources of sound and vibration and transmission pathways in buildings and building services systems
- identify propagation characteristics in free fields
- calculate an estimated fan/compressor sound power from performance data
- analyse properties of absorption, reflection and transmission for air and building materials
- determine Reverberation Time, SPL and SIL in spaces
- determine the required characteristics of 'anti-vibration' mountings and select suitable devices for building services plant

Evidence for the knowledge and/or skills for this Outcome will be provided on a sample basis. In any assessment of this Outcome a minimum of **two out of three** knowledge and/or skills items should be sampled. In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of knowledge/skill items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to both items.

Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under open-book conditions.

Assessment Guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment for this Outcome might be combined with that for Outcomes 1, 2 and 5 to form a single assessment paper.

Outcome 5

Identify elements of control systems and their performance.

Knowledge and/or Skills

- Control systems elements

Evidence Requirements

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

- explain the concepts of load variation, controlled condition, lag and deviation
- explain the construction and operation of sensing elements for temperature, pressure, humidity and flow measurement
- identify response characteristics for on-off, step, floating, proportional, integral and combined mode systems with variation of load

In any assessment of this Outcome all knowledge and/or skills items should be included. Candidates must provide a satisfactory response to all items.

Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under open-book conditions.

Assessment Guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment for this Outcome might be combined with that for Outcomes 1, 2, 3 and 4 to form a single assessment paper.

Higher National Unit specification: support notes

Unit title: Building Services Engineering Science

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 provides the underpinning theory and principles relating to thermal comfort, heat and mass transfer, fluid flow, electrical energy performance, acoustics and control systems in building services. It should be delivered using practical examples and, where possible, related to system design procedures. The Unit therefore has direct links with, and is a necessary precursor, to technology subjects. The candidate should be encouraged to produce solutions from first principles whilst appreciating the role of design data and software.

Recommended time allocations to each Outcome are given as guidance towards the depth of treatment which might be applied to each topic.

This guidance has been used in the design of the assessment exemplar material provided with the Unit.

1 Human and environmental factors influencing thermal comfort (8 hours)

Physiological and psychological factors — Affecting human sensations, thermal indices and their use in the design of building services systems. Methods of predicting and assessing thermal comfort and the reliability of design criteria.

2 Flow of heat energy and fluids (8 hours)

Heat transfer rates — Principles of heat transfer by conduction, evaporation, radiation and convection. Natural and forced convection coefficients. Stefan's constant, black and grey body radiation. One dimensional heat conduction in single and multileaf plane, cylindrical and spherical surfaces. Heat transfer rates through thermally bridged plane structures. Heat conduction rates using star and delta thermal resistance networks. Heat transfer through insulated surfaces, insulation thickness & economics. Temperature gradients and interstitial condensation risk.

Fluid flow — Principles of uniform, steady, and continuity of flow. Conservation of energy in a moving fluid, Bernoulli's equation. Fluid flow rates by use of venturi, orifice plate and pitot-static tubes.

Reynolds number — Laminar and turbulent fluid flow, boundary separation and transition Energy Losses: Use of formulae for frictional losses in pipe and duct networks including fittings and shock losses, determining frictional coefficients and velocity pressure factors. Static regain in expansion pieces. Gravitational flow in flooded and partially flooded conduits including guttering/channels, drainage pipes and soil/waste stacks. Manning, Crimp & Bruge, Darcy-Weisback and Chezy formulae.

3 Electrical energy performance (8 hours)

Electrical lighting and energy demand — Performance and calculation of typical commercial/small industrial lighting loads and calculation/comparison of before and after evaluating strategies to reduce electrical energy demand.

Electrical induction loads — Definition of an inductive load, determination of true power reactive power and apparent power. Calculation of capacitance to improve power factor of single phase induction loads.

Control of building systems — Calculation of capacitance to improve power factor of single phase induction loads.

4 Sound and vibration (8 hours)

Sound — Decibel scales, measurement of sound, equivalent continuous noise levels, sound power level (SPL), sound intensity level (SIL). Sound power/frequency spectra for external and internal noise sources. Propagation of acoustic energy, sound insulation and attenuation.

Room acoustics — Room characteristics, background and total sound levels, and reverberation time.

Vibration — Simple harmonic motion, modes of vibration, characteristics of springs, static and dynamic modulus of materials and natural frequency. Transmissibility, vibration isolation.

5 Control systems and their performance (8 hours)

Sensing elements, controllers, actuators. Analogue and digital control. On-off, step, floating, proportional, integral and combined control modes. Load, lag and deviation.

Guidance on the delivery and assessment of this Unit

The Unit should be delivered using practical examples and, where possible, related to system design procedures. The Unit has direct links with, and is a necessary precursor, to technology subjects. The candidate should be encouraged to produce solutions from first principles whilst appreciating the role of design data and software.

It is recommended that evidence for learning Outcomes is achieved through well-planned course work, assignments and projects. Assessment may be formative and summative and both may feature as part of the process. Although assessments must be focused on the individual achievement of each candidate, group work and role-play activities may contribute to the assessment. Integrative assignments and project work will help to link this Unit with other related Units.

The volume of evidence required for each assessment should take into account the overall number of assessments being contemplated within this Unit and the design of the overall teaching programme.

In designing the assessment instrument/s, opportunities should be taken to generate appropriate evidence to contribute to the assessment of Core Skills Units.

Open learning

Given that appropriate materials exist this Unit could be delivered by distance learning, which may incorporate some degree of on-line support. However, with regard to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that assessment/s were conducted under controlled, supervised conditions.

Opportunities for the use of 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 e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

Opportunities for developing Core Skills

The Unit should be delivered using practical examples and, where possible, related to system design procedures. The Unit has direct links with, and is a necessary precursor, to technology subjects. The candidate should be encouraged to produce solutions from first principles, wherever this supports the learning and understanding, whilst appreciating the role of design data and software.

It is recommended that evidence for learning Outcomes is achieved through well-planned course work, assignments and projects. Assessment may be formative and summative and both may feature as part of the process. Although assessments must be focused on the individual achievement of each candidate, group work and role-play activities may contribute to the assessment. Integrative assignments and project work will help to link this Unit with other related Units.

The volume of evidence required for each assessment should take into account the overall number of assessments being contemplated within this Unit and the design of the overall teaching programme.

In designing the assessment instrument(s), opportunities should be taken to generate appropriate evidence to contribute to the assessment of Core Skills Units wherever appropriate.

Higher National Unit specification: support notes (cont)

Unit title: Building Services Engineering Science

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**

History of changes to Unit

Version	Description of change	Date

General information for candidates

Unit title: Building Services Engineering Science

On completion of this Unit you should be able to:

- identify human and environmental factors influencing thermal comfort
- analyse and apply basic principles to the flow of heat energy and fluids
- evaluate how the electrical energy performance of buildings can be improved
- investigate the characteristics, transmission and effects of sound and vibration
- identify elements of control systems and their performance

Evidence that you can satisfy the knowledge and skill elements of this Unit will be obtained by assessment in controlled, supervised conditions to which you will not be allowed to bring textbooks, handouts or notes to the assessment.