Higher National Unit specification: general information

Unit title: Marine Engineering: Advanced Marine Heat Engine Principles

Unit code: H0EB 35

Superclass: XQ

Publication date: January 2012

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to enable candidates to develop their knowledge and understanding in applying the principles of heat engines to the solution of problems within Marine Engineering systems.

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

1 Apply the fundamental properties of thermodynamics to a process.
2 Evaluate and apply marine heat engine cycles.
3 Calculate heat transfer through complex systems.
4 Calculate the combustion of solid, liquid and gaseous marine fuels by mass and volume.

Recommended prior knowledge and skills

It would be an advantage if candidates had a knowledge and understanding of thermodynamics. This can be evidenced by possession of the following Units: Marine Engineering: Marine Heat Engine Principles (F90Y 34) and Marine Engineering: Auxiliary Thermodynamic Principles (F90T 34). Candidates should also have a minimum of Mathematics at SCQF level 7, this may be evidence by the Unit Mathematics for Engineering 2 (DG4L 34).

General information (cont)

Credit points and level

1 Higher National Unit 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.*

Core Skills

There are opportunities to develop the Core Skill of *Numeracy* and the Core Skills components of *Communication* and Critical Thinking 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.

Higher National Unit specification: statement of standards

Unit title: Marine Engineering: Advanced Marine Heat Engine Principles

Unit code: H0EB 35

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 fundamental properties of thermodynamics to a process**.**

Knowledge and/or Skills

- The relationship between p, V and T for polytropic and adiabatic processes
- Reversible processes
- The work transfer and heat transfer for the above processes
- Specific heat at constant pressure and constant volume
- Change of entropy of a perfect gas
- p–v and T–S diagrams
- Avogadro's Law
- Universal Gas Constant

Evidence Requirements

Evidence for the Knowledge and/or Skills items in Outcome 1 should be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that they can answer correctly questions based on a sample of the knowledge and skills items listed in the Outcome. In any assessment of this Outcome, **four out of eight** 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 four out of eight Knowledge and/or Skills items are required each time the Unit is assessed. Candidates must provide a satisfactory response to all items.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Advanced Marine Heat Engine Principles

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing the candidate is able to:

- Apply the relationship between p, V and T.
- Calculate work and heat transfer for reversible processes, this should include:
  - — Constant volume process
  - — Constant pressure process
  - — Isothermal process
  - — Isentropic or Adiabatic process
  - — Polytropic process
- Calculate work and heat transfer for reversible processes
- Evaluate processes using p-V and T-S diagrams
- Solve problems relating to change of entropy for reversible processes
- Solve problems relating to Avogadro's Law
- Solve problems relating to the universal gas Constant

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 formula and correct application of the principles of the calculation.

Evidence should be generated through assessment in supervised conditions. Assessment should be conducted under closed-book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates will be permitted to use scientific calculators during the assessment.

The Evidence Requirements state that candidates must ensure answers are 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 the 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.

Outcome 2

Evaluate and apply marine heat engine cycles.

Knowledge and/or Skills

- The second law of thermodynamics
- The Carnot cycle, its thermal efficiency and apply Carnot's principle to the second law
- Ideal engine cycles described using p-V and T-S diagrams and practical counterparts applied to Marine engines
- Thermal efficiency, indicated mean effective pressure, work done and air standard efficiency of Ideal cycles
- Thermal efficiency, work and heat transfer of Gas Turbine for simple ideal and actual open and closed cycles

Evidence Requirements

Evidence for the Knowledge and/or Skills items in Outcome 2 will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that they can correctly answer questions based on a sample of the knowledge and skills items listed in the Outcome. In any assessment of this Outcome, **two out of five** 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 two from five Knowledge and/or Skills items are required each time the Unit is assessed. Candidates must provide a satisfactory response to all items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing the candidate is able to:

- Apply the second law of thermodynamics to Heat Engines
- Describe ideal and practical Heat Engine cycles using p-V and T-S diagrams
- Evaluate ideal Heat Engine cycles by solving problems relating to thermal efficiency and work done
- Analyse ideal Heat Engine cycles by comparing with the Carnot cycle
- Calculate thermal efficiency, work and heat transfer for Gas Turbine cycles

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 formula and correct application of the principles of the calculation

Evidence should be generated through assessment in supervised conditions. Assessment should be conducted under closed-book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates will be permitted to use scientific calculators during the assessment.

The Evidence Requirements state that candidates must ensure answers are 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 the 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.

Outcome 3

Calculate heat transfer through complex systems.

Knowledge and/or Skills

- Fourier's Law for conductive heat transfer.
- Heat transfer through thick cylinders, single and double lagged pipes, spheres and hemispherical ends of cylinders.
- Heat transfer through boundary layers.
- The overall heat transfer coefficient 'U' for composite flat plates and composite lagged pipes, etc, using thermal conductivity and surface heat transfer coefficient.
- Stefan Boltzmann constant.
- 'Black body' radiation and 'emissivity factor'.

Evidence Requirements

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

Evidence for the Knowledge and/or Skills items in Outcome 3 will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that they can correctly answer questions based on a sample of the knowledge and skills items listed in the Outcome. In any assessment of this Outcome, **three out of six** 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 three from six Knowledge and/or Skills items are required each time the Unit is assessed. Candidates must provide a satisfactory response to all items.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Advanced Marine Heat Engine Principles

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing the candidate is able to:

- Apply Fourier's Law for conductive heat transfer.
- Calculate heat transfer through complex systems.
- Calculate heat transfer through boundary layers.
- Calculate the overall heat transfer coefficient 'U' for composite flat plates and composite lagged pipes, etc, using thermal conductivity and surface heat transfer coefficient.
- Use the Stefan Boltzmann constant to calculate heat transfer by radiation.
- Use the 'emissivity factor' to calculate the heat radiated from a simple system.

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 formula and correct application of the principles of the calculation.

Evidence should be generated through assessment in supervised conditions. Assessment should be conducted under closed-book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates will be permitted to use scientific calculators during the assessment.

The Evidence Requirements state that candidates must ensure answers are 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 the 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.

Outcome 4

Calculate the combustion of solid, liquid and gaseous marine fuels by mass and volume.

Knowledge and/or Skills

- The combustion of fuel by mass.
- The combustion by volume for gaseous fuels.
- Stoichiometric and actual air requirements.
- Analyse total flue gas and dry flue gas by mass and by volume.
- Evaluate air supply and the proportional gravimetric constituents of a fuel from flue gas analysis.
- Evaluate the exhaust products resulting from insufficient air supply.
- HCV and LCV of fuels and the heat energy released by the various constituents.
- Apply Dalton's laws to stoichiometric and other mixtures of gaseous fuels and air.
- Determine the ‘dew point’ of water vapour from flue gas analysis.
- Evaluate the heat carried away in flue gases and heat transfer to gas to air and gas to water heat exchangers.

Evidence Requirements

Evidence for the Knowledge and/or Skills items in Outcome 4 will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that they can correctly answer questions based on a sample of the knowledge and skills items listed in the Outcome. In any assessment of this Outcome, **five out of ten** 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 five from ten Knowledge and/or Skills items are required each time the Unit is assessed. Candidates must provide a satisfactory response to all items.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Advanced Marine Heat Engine Principles

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing the candidate is able to:

- Calculate the combustion of fuel by mass.
- Calculate combustion by volume for gaseous fuels.
- Calculate the stoichiometric and actual air requirements.
- Analyse flue gas by mass or by volume.
- Calculate air supply and the proportional gravimetric constituents of a fuel from flue gas analysis.
- Calculate the exhaust products resulting from insufficient air supply.
- Calculate the approximate HCV and LCV of a fuel from the heat energy released by the various constituents.
- Apply Dalton's laws to stoichiometric and other mixtures of gaseous fuels and air.
- Calculate the 'dew point' of water vapour from flue gas analysis.
- Calculate the heat carried away in flue gases and heat transfer to gas to air and gas to water heat exchangers.

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 formula and correct application of the principles of the calculation.

Evidence should be generated through assessment in supervised conditions. Assessment should be conducted under closed-book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates will be permitted to use scientific calculators during the assessment.

The Evidence Requirements state that candidates must ensure answers are 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 the 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.

Higher National Unit specification: support notes

Unit title: Marine Engineering: Advanced Marine Heat Engine Principles

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 has been written in order to allow candidates to develop skills, knowledge and understanding of the principles of marine heat engines in the following areas:-

1 Apply the fundamental properties of thermodynamics to a process.
2 Evaluate and apply marine heat engine cycles.
3 Calculate heat transfer through complex systems.
4 Calculate the combustion of solid, liquid and gaseous marine fuels by mass and volume.

There are recommendations as to how much time should be spent on each Outcome. This has been done to help lecturers decide what depth of treatment should be given to the topics attached to each of the Outcomes. Whilst it is not mandatory for centres to use this list of topics it is strongly recommended that they do so to ensure continuity of teaching and learning.

A list of topics is given below. Lecturers are advised to study this list of so that they can get a clear indication of the standard of achievement expected of candidates in this Unit.

1 Apply the fundamental properties of thermodynamics to a process. (8 hours)

In this section it is expected that questions set should relate to real life examples, using marine terminology, as found aboard ship.

2 Evaluate and apply marine heat engine cycles. (8 hours)

In this section it is expected that calculation questions set should relate to the ideal cycles, with descriptive answer explaining how real cycles differ from the ideal. Practical cycles should relate to those found on Marine plant.

3 Calculate heat transfer through complex systems. (12 hours)

In this section it is expected that questions set should relate to real life examples, using marine terminology, as found aboard ship. Complex systems include thick cylinders, single and double lagged pipes, spheres and hemispherical ends of cylinders. Radiation problems should be for simple systems such as flat plates.

Higher National Unit specification: support notes (cont)

Unit title: Marine Engineering: Advanced Marine Heat Engine Principles

4 Calculate the combustion of solid, liquid and gaseous marine fuels by mass and volume. (12 hours)

In this section it is expected that questions set should relate to real life examples, using marine terminology, as found onboard ship. The fuels chosen for analysis should be common fuels used for Marine plant and relate to present legislation.

Guidance on the delivery of this Unit

This Unit should be delivered by a combination of whole class teaching, tutorial work and practical laboratory work where appropriate. The latter is seen as particularly important as it provides candidates with an opportunity to relate theoretical knowledge to a practical mechanical context. The Unit has been designed to incorporate sufficient time to allow lecturers to teach all the core thermodynamic principles in the Unit.

As this Unit provides core thermodynamic principles that underpin much of the studies in other areas of the HND Marine Engineering award, it is recommended that the Unit be delivered towards the start of the award.

Where this Unit is incorporated into other Group Awards it is recommended that it be delivered in the context of the specific occupational area(s) that the award is designed to cover.

The Unit has been written such that there is sufficient time built in to allow candidates to practise what they have learnt through appropriate formative assessments.

Guidance on the assessment of this Unit

The assessment for all four Outcomes could be combined together into one assessment paper which candidates should sit at one single assessment event lasting no more than two hours. Assessment should be closed book conducted under controlled supervised conditions.

A different sample of the knowledge and/or skills should be chosen when reassessing candidates.

Higher National Unit specification: support notes (cont)

Unit title: Marine Engineering: Advanced Marine Heat Engine Principles

Assessment Guidelines

Outcome 1

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

Outcome 2

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

Outcome 3

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

Outcome 4

The assessment of this Outcome could be combined together with that for Outcomes 1, 2 and 3 to form a single assessment paper. This single assessment paper should be taken at a single assessment event lasting two hours.

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

Online and Distance Learning

This Unit may be delivered by open learning, however centres will require to make arrangements for candidates to sit assessments under controlled conditions.

Higher National Unit specification: support notes (cont)

Unit title: Marine Engineering: Advanced Marine Heat Engine Principles

Opportunities for developing Core Skills

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 Outcomes 1 and 2 candidates will also be required to use graphical information to analyse solutions providing the opportunity to develop the specific Core Skill elements of Extract, analyse and interpret graphical information and Work confidently with numerical or statistical methods.

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. This will allow candidates to develop the specific Core Skill elements Assess the relevance of these factors to the situation or issue and Develop and justify an approach to deal with the situation or issue.

In the answering of assessment work candidates may have the opportunity to develop Written Communication of the Core Skill *Communication* at SCQF level 6. The specific Core Skill elements that the candidate may have to complete are Use conventions which are effective in achieving the purpose of the piece and adapted as necessary for the target audience.

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: Marine Engineering: Advanced Marine Heat Engine Principles

This Unit has been designed to allow you to further develop knowledge, skills and understanding in Heat Engine principles and concepts.

This Unit will also provide you with an opportunity to study the theoretical and practical operating cycles for different types of Heat Engines.

This Unit will also allow you the opportunity to develop the necessary knowledge and skills to evaluate heat transfer to surroundings through complex walls.

You will also learn to evaluate Heat Engines by analysing the products of combustion and to produce an associated heat balance.

It is good to gain sound theoretical knowledge and understanding but it is also important that you are able to set your theoretical knowledge within a practical Mechanical context. Thus, it is likely during the Unit you will be provided with the opportunity to relate theory to practice by doing practical experiments.

The formal assessment for this Unit will consist of a single assessment paper lasting no more than two hours. The assessment will be conducted under closed-book conditions in which you will not be allowed to take notes, textbooks, etc into the assessment. However, you will be allowed to use a scientific calculator. You will sit this assessment paper at the end of the Unit.

This Unit will consist of four Outcomes that you will study:

1 Apply the fundamental properties of thermodynamics to a process.
2 Evaluate and apply marine heat engine cycles.
3 Calculate heat transfer through complex systems.
4 Calculate the combustion of solid, liquid and gaseous marine fuels by mass and volume.

There are opportunities in this Unit to develop a component of the Core Skill Numeracy at SCQF level 6 as you will perform calculations, manage formulae and equations. You will also be able to develop a component of the Core Skill of Problem Solving at SCQF level 6 in the interpretation of the problems you solve in this Unit. Finally, you will have the opportunity to develop a component of the Core Skill of Communication at SCQF level 6.