

Higher National Unit specification



General information for centres

Unit title: Marine Engineering: Marine Heat Engine Principles

Unit code: F90Y 34

Unit purpose: This Unit is designed to enable candidates to develop the knowledge and understanding required to apply the principles of heat engines to the solution of problems within Marine Engineering systems. The Unit will also provide the candidate with a base from which future advanced work in Marine Engineering may be undertaken.

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

- 1 Calculate and explain the effect of applying heat energy to solids and liquids.
- 2 Apply the Gas Laws for non-flow systems and evaluate the work done.
- 3 Apply the First Law of Thermodynamics to closed and open systems.
- 4 Explain the combustion cycles associated with Marine Engines and evaluate power and efficiency from test data.

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: It would be an advantage if candidates had a knowledge and understanding of basic thermodynamics. This can be evidenced by possession of the following NQ Unit: Marine Heat Engines (F7HG 12) at SCQF level 6. In addition it would be beneficial if candidates possessed a SQA Unit in mathematics at SCQF level 6.

Core skills: There are opportunities to develop the Core Skill of *Numeracy, Communication* and *Problem Solving* 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: 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 conducted under controlled, supervised conditions.

Higher National Unit specification: statement of standards

Unit title: Marine Engineering: Marine Heat Engine Principles

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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

Calculate and explain the effect of applying heat energy to solids and liquids.

Knowledge and/or skills

- ◆ heat energy, sensible heat, latent heat.
- ◆ change of phase diagram for water.
- ◆ resultant temperature when a solid is placed in a liquid at a different temperature.
- ◆ resultant temperature when up to three liquids at different temperatures are mixed.
- ◆ coefficient of linear expansion and coefficient of cubical expansion
- ◆ heat transfer by conduction, convection, radiation.
- ◆ heat transfer through a composite wall of no more than three flat layers in contact.
- ◆ heat transfer from a flat surface.

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.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Marine Heat Engine Principles

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.

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:

- ◆ Explain latent and sensible heat.
- ◆ Sketch change of phase diagrams for water at different pressures.
- ◆ Calculate the resultant temperature when placing a solid in a liquid at a different temperature.
- ◆ Calculate the resultant temperature when three liquids at different temperatures are combined.
- ◆ Calculate change in dimensions when heat is added to liquids and solids
- ◆ Explain, relating to Marine Heat Engines, the different methods of transfer of heat, and the influencing factors.
- ◆ Calculate the heat transfer through a composite wall of not more than three flat layers in contact
- ◆ Calculate the heat transfer from a flat surface to its surroundings.

Where calculations are performed the candidate must:

- ◆ apply appropriate formulae.
- ◆ apply the principles of the calculation.
- ◆ show all working through a calculation.
- ◆ ensure the answer is derived from the application of the formula and correct application of the principles of the calculation.

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 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.

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.

Assessment guidelines

The assessment of this Outcome could be combined together with that for Outcomes 2, 3 and 4 to form a single assessment paper, details of which are given under the Evidence Requirements for Outcome 4.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Marine Heat Engine Principles

Outcome 2

Apply the Gas Laws for non-flow systems and evaluate the work done.

Knowledge and/or skills

- ◆ ideal gas laws
- ◆ isothermal, adiabatic and polytropic operations
- ◆ process diagrams
- ◆ specific heat capacities of a gas at constant pressure and at constant volume.
- ◆ change in internal energy
- ◆ the relationship between the Characteristic Gas Constant and the specific heat capacities of a gas.
- ◆ non-flow processes.

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, **four out of seven** 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 from seven 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:

- ◆ Calculate gas properties using the gas laws:
 - Boyle's law
 - Charles' law
 - Combined gas law
 - Characteristic gas equation.
- ◆ Define Isothermal, Adiabatic and Polytropic operations.
- ◆ Draw process diagrams to demonstrate the above operations.
- ◆ Calculate specific heat capacity at constant pressure and constant volume.
- ◆ Calculate the change of internal energy.
- ◆ Apply the relationship between characteristic gas constant and specific heat capacities.
- ◆ Evaluate the work done on non-flow processes.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Marine Heat Engine Principles

Where calculations are performed the candidate must:

- ◆ apply appropriate formulae.
- ◆ apply the principles of the calculation.
- ◆ show all working through a calculation.
- ◆ ensure the answer is derived from the application of the formula and correct application of the principles of the calculation.

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 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.

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.

Assessment guidelines

The assessment of this Outcome could be combined together with that for Outcomes 1, 3 and 4 to form a single assessment paper, details of which are given under the Evidence Requirements for Outcome 4.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Marine Heat Engine Principles

Outcome 3

Apply the First Law of Thermodynamics to closed and open systems.

Knowledge and/or skills

- ◆ Internal Energy.
- ◆ Joules Law for the internal energy of a gas.
- ◆ Thermodynamic systems — open and closed.
- ◆ First Law of Thermodynamics.
- ◆ Closed Thermodynamic systems — change in internal energy.
- ◆ Open Thermodynamic systems — change in internal energy.
- ◆ Work and power with reference to a thermodynamic system.

Evidence requirements

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, **four out of seven** 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 from seven 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:

- ◆ Define internal energy.
- ◆ Calculate the internal energy of a gas.
- ◆ Define and give at least two examples relating to Marine Heat Engines of open and closed thermodynamic systems.
- ◆ State the First Law of Thermodynamics.
- ◆ Calculate heat supplied, change in internal energy, work done on closed thermodynamic systems.
- ◆ Calculate heat supplied, change in internal energy, work done on open thermodynamic systems.
- ◆ Calculate power developed by thermodynamic systems.

Where calculations are performed the candidate must:

- ◆ apply appropriate formulae.
- ◆ apply the principles of the calculation.
- ◆ show all working through a calculation.
- ◆ ensure the answer is derived from the application of the formula and correct application of the principles of the calculation.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Marine Heat Engine Principles

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 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.

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.

Assessment guidelines

The assessment of this Outcome could be combined together with that for Outcomes 1, 2 and 4 to form a single assessment paper, details of which are given under the Evidence Requirements for Outcome 4.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Marine Heat Engine Principles

Outcome 4

Explain the combustion cycles associated with Marine Engines and evaluate power and efficiency from test data.

Knowledge and/or skills

- ◆ Ideal Cycles associated with Marine Heat Engines. (Otto, Diesel, Dual)
- ◆ Practical cycles associated with Marine Heat Engines
- ◆ Indicated and brake powers
- ◆ Thermal and mechanical efficiency
- ◆ Specific fuel consumption.
- ◆ Exhaust gas products — stoichiometric air conditions
- ◆ Exhaust gas products — excess air conditions
- ◆ Heat energy balance for a Marine internal combustion engine.

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, **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.

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:

- ◆ Sketch and explain Ideal Cycles associated with Marine Heat Engines.
- ◆ Compare Ideal Cycles with practical cycles.
- ◆ Calculate indicated and brake power of a Marine internal combustion engine when supplied with engine test data or performance curves.
- ◆ Calculate mechanical and thermal efficiency of a Marine internal combustion engine when supplied with engine test data or performance curves.
- ◆ Calculate specific fuel consumption from engine test data.
- ◆ Calculate exhaust gas products by mass for stoichiometric air conditions.
- ◆ Calculate exhaust gas products by mass for excess air conditions.
- ◆ Produce a heat energy balance for a Marine internal combustion engine.

Where calculations are performed the candidate must:

- ◆ apply appropriate formulae.
- ◆ apply the principles of the calculation.
- ◆ show all working through a calculation.
- ◆ ensure the answer is derived from the application of the formula and correct application of the principles of the calculation.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Marine Heat Engine Principles

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 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.

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.

Assessment guidelines

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

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

Administrative Information

Unit code: F90Y 34
Unit title: Marine Engineering: Marine Heat Engine Principles
Superclass category: XQ
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History of changes:

Version	Description of change	Date

Source: SQA

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Higher National Unit specification: statement of standards

Unit title: Marine Engineering: 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 Calculate and explain the effect of applying heat energy to solids and liquids.
- 2 Apply the Gas Laws for non-flow systems and evaluate the work done.
- 3 Apply the First Law of Thermodynamics to closed and open systems.
- 4 Explain the combustion cycles associated with Marine Engines and evaluate power and efficiency from test data.

In designing this Unit, the Unit writer has identified the range of topics expected to be covered.. Recommendations are also given 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 Calculate and explain the effect of applying heat energy to solids and liquids. (10 hours)

In this section it is expected that questions set should relate to real life examples, using marine terminology, as found aboard ship. For example the effects of applying heat to cylinder liners and exhaust valves, fitting of valve seats and bearings, transfer of heat through insulated bulkheads, mixing of oils or water at different temperatures, the effect of applying heat to water in all of its phases, sensible and latent heat.

2 Apply the Gas Laws for non-flow systems and evaluate the work done. (10 hours)

In this section it is expected that questions set should include solving problems for a variety of different perfect gases and the non-flow thermodynamic processes, isothermal, adiabatic and polytropic. pV diagrams can be used to represent these processes and the area indicates work done.

3 Apply the First Law of Thermodynamics to closed and open systems. (10 hours)

In this section it is expected that questions set should include solving problems for different thermodynamic processes, closed system with fixed boundary, closed system with elastic boundary, open system with fixed boundary. The non-flow and the steady flow energy equation should be used to determine work done in thermodynamic processes.

4 Explain the combustion cycles associated with Marine Engines and evaluate power and efficiency from test data. (10 hours)

In this section it is expected that questions set should relate to real life examples, using marine terminology, as found aboard ship. Cycles should include Otto, Diesel and Dual with pV diagrams used to compare with practical cycles. Power, efficiency, fuel consumption should be determined from data in tabulated and graphical form. The heat balance should be obtained for the complete combustion of typical marine fuels.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Marine Heat Engine Principles

Guidance on the delivery and assessment 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 HNC and HND Marine Engineering awards, it is recommended that the Unit be delivered towards the start of these awards.

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.

Details on the approaches to assessment are given under Evidence Requirements and Assessment Guidelines in Outcome 4 of the Higher National Unit specification: statement of standards section. It is recommended that this section is read carefully before proceeding with assessment of candidates.

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 component ‘Using Number’ core skill of *Numeracy* at SCQF level 6. This work will allow candidates to develop the specific core skill elements of ‘Carry out a number of sustained, complex calculations’. In Outcome 4 candidates will also be required to interpret complex tabulated and graphical information again providing the opportunity to develop the component ‘Using Graphical Information’ of the core skill *Numeracy* at SCQF level 6. This will allow the candidate to develop the specific skills ‘Extract, analyse, and interpret graphical information’.

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 and justify an approach to deal with a situation or issue’.

When candidates are working through Outcomes there is an opportunity for Lecturers to question candidates. This questioning of candidates provides opportunities to reinforce theories. Candidates may have the opportunity to develop the component ‘Oral Communication’ of the core skill *Communication* at SCQF level 6. Candidates may complete an explanation of a complex theory and may have the opportunity to complete the specific core skills ‘Convey all essential information, opinions, or ideas with supporting detail accurately and coherently, and with varied emphasis as appropriate’, ‘Structure communication to take full account of purpose and audience’ and ‘Take account of the situation and audience during delivery’.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Marine Heat Engine Principles

Open learning

This Unit would be suitable for candidates unable to attend college on a regular basis and could be delivered by distance learning. However the assessment of this Unit would require the candidate's attendance at an assessment centre.

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

General information for candidates

Unit title: Marine Engineering: Marine Heat Engine Principles

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

The Unit will provide you with an opportunity to study the relationships that exist between pressure, volume and temperature as well as evaluate properties and changes of state for perfect gases and vapours.

The Unit will also allow you the opportunity to develop the necessary knowledge and skills to evaluate energy transfers for perfect gases and vapours. This evaluation is the basis for applying thermodynamic principles to specified thermodynamic systems.

You will also learn to apply thermodynamic theory to Marine Plant in order to assess the overall performance.

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 may 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 4 Outcomes that you will study:

- 1 Calculate and explain the effect of applying heat energy to solids and liquids.
- 2 Apply the Gas Laws for non-flow systems and evaluate the work done.
- 3 Apply the First Law of Thermodynamics to closed and open systems.
- 4 Explain the combustion cycles associated with Marine Engines and evaluate power and efficiency from test data.