



National Unit Specification: general information

UNIT Marine Heat Engines (SCQF level 6)

CODE F7HG 12

SUMMARY

This Unit is designed to provide candidates with knowledge and understanding of engineering thermodynamics applied to marine heat engines. During delivery of the Unit candidates will learn to determine the effects of applying heat energy to solids, liquids and gases and sketch thermodynamic properties on pressure-volume (p-V) diagrams. Candidates will also develop the knowledge and understanding to solve problems involving the non-flow and steady flow energy equations. The candidates will also learn about combustion of marine grade fuels.

OUTCOMES

- 1 Determine the effects of applying heat energy to solids and liquids.
- 2 Describe heat transfer and the effect of insulation.
- 3 Determine the properties of working fluids and sketch thermodynamic processes on p-V diagrams.
- 4 Determine the energy of different marine thermodynamic systems using the non-flow and steady flow energy equations.
- 5 Explain, using an analysis by mass, the combustion of marine grade fuels.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following, or equivalent:

- ◆ Standard Grade Mathematics at credit level
- ◆ Standard Grade Physics at credit level
- ◆ Intermediate 2 Physics

Administrative Information

Superclass: ZF

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National Unit Specification: general information (cont)

UNIT Marine Heat Engines (SCQF level 6)

CREDIT VALUE

1 credit(s) at SCQF level 6 (6 SCQF credit points at SCQF level 6)

**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 the following Core Skills in this Unit:

- ◆ *Communication*: Written at SCQF level 5
- ◆ *Communication*: Reading at SCQF level 5
- ◆ *Numeracy*: Using Number at SCQF level 5
- ◆ *Problem Solving*: Critical Thinking at SCQF level 5

There is no automatic certification of Core Skills or Core Skills components.

National Unit Specification: statement of standards

UNIT Marine Heat Engines (SCQF level 6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit Specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Determine the effects of applying heat energy to solids and liquids.

Performance Criteria

- (a) State correctly practical examples, related to the marine industry, of thermal expansion and contraction.
- (b) Solve problems relating to change of temperature and change of dimensions of solids and liquids.
- (c) Solve problems relating to mass, specific heat capacity and temperature change.
- (d) Describe how changes of state occur without change of temperature.

OUTCOME 2

Describe heat transfer and the effect of insulation.

Performance Criteria

- (a) Define correctly and give examples of conduction, convection and radiation applied to the marine industrial environment.
- (b) Correctly identify the direction of transfer of heat energy.
- (c) Determine correctly the heat transfer through a single wall.
- (e) Correctly state the effects of insulation on heat transfer.

OUTCOME 3

Determine the properties of working fluids and sketch thermodynamic processes on p-V diagrams

Performance Criteria

- (a) Explain correctly the meaning of the term working fluid and the concept of the state of the working fluid.
- (b) Apply correctly the gas equations and determine the properties of ideal gases.
- (c) Sketch correctly thermodynamic processes on p-V diagrams for an ideal gas.
- (d) Determine correctly the properties of vapours using thermodynamic property tables.

National Unit Specification: statement of standards (cont)

UNIT Marine Heat Engines (SCQF level 6)

OUTCOME 4

Determine the energy of different marine thermodynamic systems using the non-flow and steady flow energy equations.

Performance Criteria

- (a) State correctly the types of energy and their units relevant to marine thermodynamic systems.
- (b) State correctly the terms in the non-flow energy equation.
- (c) Apply correctly the non-flow energy equation to closed marine thermodynamic systems.
- (d) State correctly the terms in the steady flow energy equation.
- (e) Apply correctly the steady flow energy equation to an open marine thermodynamic system.

OUTCOME 5

Using an analysis by mass, explain the combustion of marine grade fuels.

Performance Criteria

- (a) State correctly the types of fuels available for use in marine internal combustion engines and boilers.
- (b) State correctly the combustion equations for carbon, hydrogen and sulphur.
- (c) Define correctly higher and lower calorific values of a marine fuel.
- (d) Accurately calculate the combustion analysis of a marine grade fuels by mass.
- (e) State correctly the effect of insufficient and excess air in relation to marine internal combustion engines and boilers.

EVIDENCE REQUIREMENTS FOR THIS UNIT

Evidence is required to demonstrate that candidates have achieved all Outcomes and Performance Criteria.

Written and/or recorded oral evidence should be produced to demonstrate that a candidate has achieved all Outcomes and Performance Criteria.

Outcomes 1, 2, 3, 4 and 5 may be assessed on an individual basis, as a combination of Outcomes (eg Outcomes 1 and 2 assessed together and Outcomes 3 and 4 and 5 together), or as a single, holistic assessment covering all five Outcomes. The total time for assessment(s) of the five Outcomes must not exceed two hours. Assessment(s) must be conducted under supervised, closed-book conditions in which candidates may use reference materials provided by the centre but are not allowed to bring their own notes, handouts, textbooks or other materials into the assessment. Candidates should be allowed to use a non-programmable scientific calculator during assessment.

National Unit Specification: statement of standards (cont)

UNIT Marine Heat Engines (SCQF level 6)

Outcome 1

- ◆ Candidates must apply the co-efficient of expansion for both linear and cubical expansion.
- ◆ Candidates must solve problems involving heating and cooling of solids without change of state.
- ◆ Candidates must define freezing and boiling points, specific enthalpy of fusion and specific enthalpy of evaporation.
- ◆ Candidates must differentiate between sensible heat and latent heat.

Outcome 2

- ◆ Candidates must determine the heat transfer through a single wall when the fluids on either side are stationary.
- ◆ Candidates must determine external temperatures for conducting and insulating materials.

Outcome 3

- ◆ Candidates must apply the universal and the characteristic gas equations to an ideal gas, making use of both specific and universal gas constants.
- ◆ Candidates must determine and use the properties of an ideal gas (both specific and total where appropriate). The properties must include: pressure, temperature, volume, specific heats, internal energy and enthalpy.
- ◆ Candidates must sketch the following processes for an ideal gas on a p-V diagram: constant pressure, constant volume and constant temperature.
- ◆ Candidates must determine the properties of a saturated vapour and a superheated vapour from thermodynamic property tables (both specific and total where appropriate). The properties must include: pressure, temperature, volume, dryness fraction, internal energy and enthalpy.

Outcome 4

- ◆ Candidates must identify each of the following forms of energy, and their units, relevant to thermodynamic systems: heat, work, kinetic energy, gravitational potential energy, pressure energy, internal energy and enthalpy.
- ◆ Given the non-flow energy equation, candidates must state each of the terms in the equation, and apply it to solve problems relating to energy transfers in processes taking place in simple closed systems. Working fluid must include both an ideal gas and a vapour, and values of properties should be determined as appropriate for the fluids.
- ◆ Given the steady flow energy equation, candidate must state each of the terms in the equation, and apply it correctly to solve problems relating to energy transfers in simple open systems. The working fluid must include both an ideal gas and a vapour, and values of properties should be determined as appropriate for the fluids.

Outcome 5

- ◆ Candidates must give chemical symbols of basic elements associated with combustion.
- ◆ Candidates must determine theoretical or stoichiometric air for complete combustion of a fuel by mass.

National Unit Specification: support notes

UNIT Marine Heat Engines (SCQF level 6)

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 forms part of the National Certificate in Shipping and Maritime Operations at SCQF level 6, but may also be offered on a free standing basis.

The aim of this Unit is to provide candidates with knowledge and understanding of engineering thermodynamics applied to a marine engine. During delivery of the Unit candidates will learn to determine the effects of applying heat energy to solids, liquids and gases and sketch thermodynamic properties on pressure-volume (p-V) diagrams. Candidates will also develop the knowledge and understanding to solve problems involving the non-flow and steady flow energy equations. The candidates will also learn about marine grade fuel and their combustion.

Due to the close relationship between the content of Outcomes 1 and 2 and of Outcomes 3 and 4, centres may choose to integrate their delivery. In Outcome 3, candidates should be introduced to the concept of the working fluid, and its importance in thermodynamic systems and plant. A limited number of properties should be determined for both ideal gases and vapours, and these should be used to enable p-V diagrams to be drawn for an ideal gas. This knowledge of the working fluid and its properties should be carried forward into Outcome 4, in which energy transfers are calculated for open and closed systems. The emphasis should be on the correct use of the energy equations, rather than simply memorising formulae. With regard to Outcome 4 pc(c), processes covered may typically involve a closed system with a fluid contained in a cylinder behind a piston. In Outcome 4 pc (e) the open system could be a simplified steam plant, or an internal combustion engine, in each case with calculations being based on fluid energy at inlet and outlet, and work and heat energy transfers.

National Unit Specification: support notes (cont)

UNIT Marine Heat Engines (SCQF level 6)

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

It is recommended that the Unit is delivered in the same sequence the Outcomes are presented in the National Unit Specification: statement of standards section of the Unit. The Unit may be delivered by a combination of lectures, tutorial work, computer simulation and laboratory work. While the majority of the Unit can be delivered in a classroom centres should allow candidates to undertake practical thermofluid experiments so that they have opportunities to relate theory learnt in the classroom to practice. For example, where equipment exists candidates should be allowed to perform simple experiments involving manometry to calculate fluid pressures.

Computer simulation illustrating different thermodynamic concepts and principles may also provide a good source of learning.

The internet contains a rich source of materials on engineering thermodynamics. Wall charts illustrating different thermodynamics concepts and principles can also be a very useful learning and teaching aid.

The Unit should be fully supported with relevant learning materials (eg handouts in paper and electronic form, textbooks, on-line materials etc).

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

Opportunities for developing the Core Skill of *Numeracy*: Using Number at SCQF level 5 may be developed in all five Outcomes while candidates are manipulating and solving equations to solve problems in engineering thermofluids.

Candidates may have opportunities to develop the Core Skill of *Numeracy*: Using Graphical Information at SCQF level 5 in Outcome 3 while sketching pressure volume diagrams for thermodynamic processes.

Opportunities for developing the Core Skill of *Problem Solving*: Critical Thinking at SCQF level 5 may be developed in all five Outcomes while candidates solve problems in engineering thermodynamics.

There are also opportunities to develop the Core Skill of *Communications* (both Reading and Written at SCQF level 5) as candidates will have to be able to read tabular information and higher level text books plus written work will have to be presented in a logical and accurate format.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Centres are encouraged to use formative assessment extensively as it plays a particularly important role in allowing candidates to develop a sound knowledge and understanding of engineering thermodynamic concepts, principles and equations.

Regardless of whether assessment is carried out on an individual basis, as a combination of Outcomes or on a single, holistic basis any assessment paper(s) used may comprise a suitable balance of short answer, restricted response and structured questions.

National Unit Specification: support notes (cont)

UNIT Marine Heat Engines (SCQF level 6)

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 Communications 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)*.

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).