SQA Advanced Unit Specification

General information

Unit title: Marine Engineering: Thermodynamics (SCQF Level 7)

Unit code: HW5F 47

Superclass: XQ

Publication date: November 2017

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This unit is designed to enable learners to develop the knowledge and understanding required to apply the principles of thermodynamic processes to the solution of problems within the marine engineering environment. It is designed as part of the SQA Advanced Certificate in Marine Engineering Award for training Merchant Navy Officers, and will provide the learner with a clear path of progression onto SQA Advanced Diploma level study in Thermodynamics.

Outcomes

On successful completion of the unit the learner will be able to:

1 calculate and explain the effect of applying heat energy to solids and liquids
2 apply the gas laws for thermodynamic systems and evaluate the work done
3 explain and analyse combustion cycles associated with marine engines
4 apply the data from property tables to solve problems on processes

Credit points and level

1 SQA credit at SCQF level 7: (8 SCQF credit points at SCQF level 7)

Recommended entry to the unit

Entry is at the discretion of the centre, however a minimum SCQF level 5 Mathematics and the completion of a Level 3 Diploma in Shipping and Maritime Operations (Engineering) would be beneficial.

Core skills

Achievement of this unit gives automatic certification of the following core skills component:

Complete core skill	None
Core skill component	Using Number at SCQF level 6 Critical Thinking at SCQF level 5

There are also opportunities to develop aspects of core skills which are highlighted in the support notes of this unit specification.

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.

The Assessment Support Pack (ASP) for this unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website.

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

SQA Advanced Unit Specification: Statement of standards

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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 SQA.

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. Learners 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
- 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

Outcome 2

Apply the gas laws for thermodynamic systems and evaluate the work done.

Knowledge and/or skills

- Ideal gas laws
- Isothermal, adiabatic and polytropic processes process diagrams
- Specific heat capacities of a gas at constant pressure and at constant volume
- Change in internal energy
- Steady flow processes
- Non-flow processes

Outcome 3

Explain and analyse combustion cycles associated with marine engines.

Knowledge and/or skills

- Ideal cycles associated with marine heat engines
- Practical cycles associated with marine heat engines
- Indicated and brake powers
- Thermal and mechanical efficiency
- Calorific values
  - — Exhaust gas products — stoichiometric air conditions
  - — Exhaust gas products — excess air conditions

Outcome 4

Apply the data from property tables to solve thermodynamic process problems.

Knowledge and/or skills

- Refrigerant and insulation material
- Principle components of a vapour compression refrigeration system
- P-H diagram to describe the quality of a refrigerant or steam
- Property tables to determine the specific enthalpy and specific volume of wet, dry and superheated working fluids
- Coefficient of performance and capacity
- Change of phase diagram for ice, water and steam
- Final condition of a vapour after throttling

Evidence requirements for this unit

Written and/or oral evidence should be generated through assessment in supervised conditions. Assessment should be conducted under closed-book conditions and as such learners should not be allowed to bring any textbooks, handouts or notes to the assessment.

The assessment for all four outcomes should be combined together into one assessment paper which learners should sit at one single assessment event lasting no more than two and a half hours.

Learners will be permitted to use scientific calculators during the assessment.

Where calculations are performed the learner 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.

The evidence requirements state that learners 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 learners’ 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 1

Evidence for the knowledge and or skills in this outcome will be provided on a sample basis. Written and/or oral evidence based on a sample of **four from six** knowledge and/or skills item should be provided in any assessment of this outcome.

In order to ensure that the learners will not be able to foresee what items they will be questioned on, a different sample of four out of six knowledge and/or skills items is required each time the outcome is assessed.

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

- explain sensible and latent heat
- calculate the resultant temperature when placing a solid in a liquid at a different temperature
- calculate the resultant temperature when up to three liquids at different temperatures are combined
- calculate change in dimensions when heat is added to liquids and solids
- explain in relation to Marine Heat Engines, the different methods of heat transfer, and the influencing factors
- calculate the heat transfer through a composite wall of not more than three flat layers in contact with each other

Outcome 2

Evidence for the knowledge and or skills in this outcome will be provided on a sample basis. Written and/or oral evidence based on a sample of **five from seven** knowledge and/or skills item should be provided in any assessment of this outcome.

In order to ensure that the learners will not be able to foresee what items they will be questioned on, a different sample of five from seven knowledge and/or skills items is required each time the outcome is assessed.

Where sampling takes place, a learner's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the learner 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 processes
- draw isothermal, adiabatic and polytropic process diagrams
- calculate specific heat capacities of a gas at constant pressure and constant volume
- calculate change in internal energy
- calculate unknowns in a steady flow processes
- evaluate work done on non-flow processes

Outcome 3

Evidence for the knowledge and or skills in this outcome will be provided on a sample basis. Written and/or oral evidence based on a sample of **five from seven** knowledge and/or skills item should be provided in any assessment of this outcome.

In order to ensure that the learners will not be able to foresee what items they will be questioned on, a different sample of five from seven knowledge and/or skills items is required each time the outcome is assessed.

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

- sketch and explain ideal cycles associated with marine heat engines
- compare and contrast ideal cycles with practical
- calculate indicated and brake power of a marine internal combustion engine
- calculate mechanical and thermal efficiency of a marine internal combustion engine
- calculate calorific values of fuels
- calculate exhaust gas products by volume for stoichiometric air conditions
- calculate exhaust gas products by volume for excess air conditions

Outcome 4

Evidence for the knowledge and or skills in this outcome will be provided on a sample basis. Written and/or oral evidence based on a sample of **five from seven knowledge and/or skills** item should be provided in any assessment of this outcome.

In order to ensure that the learners will not be able to foresee what items they will be questioned on, a different sample of five from seven knowledge and/or skills items is required each time the outcome is assessed.

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

- determine appropriate refrigerants and insulation material
- explain the operation of, and identify the principle components of a vapour compression refrigeration system
- use a pressure – enthalpy diagram to explain the quality of a refrigerant or water vapour
- use property tables to determine the specific enthalpy and specific volume of wet, dry and superheated working fluids
- calculate coefficient of performance and capacity
- sketch and explain a change of phase diagram for ice, water and steam at varying pressures
- calculate from given data, the final condition of a vapour after throttling

SQA Advanced Unit Support Notes

Unit title: Marine Engineering: Thermodynamics (SCQF Level 7)

Unit Support Notes are offered as guidance and 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 learners to develop knowledge, understanding and skills in the following areas:

1 Calculate and explain the effect of applying heat energy to solids and liquids.
2 Apply the gas laws for thermodynamic systems and evaluate the work done.
3 Explain and analyse combustion cycles associated with Marine Engines.
4 Use Thermodynamic Property Tables to solve problems on processes.

In each section it is advised that the question set should relate to terminology used on board ship.

1 Calculate and explain the effect of applying heat energy to solids and liquids. (10 hours)

- Heat exchangers in the marine engineering environment
- Expansion and contraction of machinery components made from different metals
- Changing temperature of fuel oil, ballast and cargo tanks
- Insulation material used in accommodation, cool rooms, cargo space and refrigerators
- Fire and water tube boilers

2 Apply the gas laws for thermodynamic systems and evaluate the work done. (10 hours)

- Air and refrigerant compressors
- Internal combustion engines used in the marine engineering environment
- Ballast, fuel and fire pumps
- Boilers, economisers and condensers
- Compressed air receivers

3 Explain and analyse combustion cycles associated with marine engines. (10 hours)

- Boiler fuel and flue gases
- Diesel engine fuel and flue gases
- Test data from marine internal combustion engines

4 Use Thermodynamic Property Tables to solve problems on processes. (10 hours)

- Refrigerators, cool rooms and cargo refrigeration equipment
- Boilers and steam turbines
- Condensers
- Exhaust gas boilers
- Feed water heaters

This module is designed to fall in line with the requirements of the industry's IAMI (International Association of Maritime Institutions) Science A Syllabus at EOOW (Engineer Officer of the Watch) level.

This module provides a progression path onto the marine engineering SQA Advanced Diploma in Mechanics modules.

Guidance on approaches to delivery of this unit

The unit may be delivered by a suitable balance of lectures, tutorial work, computer simulation, practical laboratory work and industrial visits. Practical demonstration and realistic problem solving should support the application of thermodynamic principles and concepts. Computer software could be made available where appropriate and learners should be encouraged to take a logical problem solving approach throughout.

The unit has been written such that there is sufficient time built in for learners to practice what they have learnt through appropriate formative assessment exercises. Additionally, the unit has been designed to incorporate time for experimental work and computer simulations so that learners have an opportunity to confirm theories in practice. Whilst it is recognised that computer simulation can be a valuable tool in confirming thermodynamic theories, it is nevertheless felt important that learners do some practical laboratory work so that they can gain experience in using test equipment and analysing the results of experiments.

The majority of this unit can be delivered in a classroom environment, however some aspects may be delivered during ship visit tours of varying engine rooms or in a machinery workshop, such practical environments will help learners assimilate thermodynamic principles and theories in a workplace setting.

As this unit provides core dynamics and principles which underpin much of the studies done in other areas of the SQA Advanced Certificate and SQA Advanced Diploma in Marine Engineering awards it is recommended that the unit be delivered towards the start of these awards.

Guidance on approaches to assessment of this unit

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

Evidence can be generated using different types of assessment. The following are suggestions only, there may be other methods that would be more suitable to learners.

The assessment for all four outcomes of this unit should be combined together into one assessment paper. This paper could be taken by learners at one single assessment event that should last 2.5 hours. Assessment should be conducted under closed-book, controlled and supervised conditions. Learners are permitted to use a scientific calculator but not a programmable calculator and a copy of thermodynamic property tables should be provided. Where sampling is used an alternative sample should be used when reassessing learners. Assessment should take place under invigilated conditions and follow the assessment centres examination policy.

Opportunities for 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 social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the evidence requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing core and other essential skills

In all outcomes each of the assessments requires the learner to be able to solve problems involving thermodynamics. This will give the learner the opportunity to develop the component 'Using Number' of the Core Skill Numeracy at SCQF level 5 and 6. The specific core skill elements that the learner will have to complete are 'Work confidently to solve a numerical problem' SCQF level 5 and 'Carry out a number of sustained, complex calculations' SCQF level 6.

The assessment of this unit may also contribute towards the component 'Written Communication (writing)' of the Core Skill Communication at SCQF level 6. Learners may have to structure their responses, which could include varying structure and presenting essential information in a logical manner. The specific core skill elements that learners may have to complete are 'Present all essential ideas/information and supporting detail in a logical and effective order' and 'Vary sentence structure, paragraphing, and vocabulary to suit the purpose and target audience'.

In all outcomes learners have an opportunity to apply graphical skills when interpreting and presenting information. This will give the learner the opportunity to develop the component 'Using graphical information' of the Core Skill Numeracy at SCQF level 6. In the drawing of pressure - volume and pressure – enthalpy graphs learners will develop the specific core skill elements 'Extract, analyse, and interpret graphical information' and 'Select an appropriate form of complex table, chart, diagram, or qualitative form and communicate complex information in that form'.

There may also be opportunities to gather evidence towards core skills in Problem Solving at SCQF level 6, and Information and Communication Technology (ICT) at SCQF level 4.

The Critical Thinking Core Skill component at SCQF level 6 may be developed in all four outcomes while learners apply thermodynamics theory to solve engineering problems.

Learners will be able to consider any harmful effects that marine engineering operations may have upon the environment and be given the opportunity to mitigate them, for example fuel oil selection, pollution control and ballast water management. Consideration can also be given to sustainability in the selection and recycling of materials used in the workplace such as insulation material, machinery components.

This unit has the Using Number component of Numeracy and the Critical Thinking component of Problem Solving embedded in it. This means that when learners achieve the unit, their core skills profile will also be updated to show they have achieved Using Number at SCQF level 6 and Critical Thinking at SCQF level 5.

History of changes to unit

Version	Description of change	Date

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

General information for learners

Unit title: Marine Engineering Thermodynamics (SCQF Level 7)

This section will help you decide whether this is the unit for you by explaining what the unit is about, what you should know or be able to do before you start, what you will need to do during the unit and opportunities for further learning and employment.

This unit has been designed to allow you to develop knowledge, understanding and skills in thermodynamic concepts and theorems that underpin so much of more advanced studies in Marine Engineering. If you have studied thermodynamics before the early parts of this unit it will provide you with an opportunity to revise the concepts and theorems you have learnt previously.

Your learning will be enhanced when you can apply the theoretical knowledge to a practical marine engineering environment. It may be the case that during the unit, you will have the opportunity to relate these theories and practices by the use of computer simulation. You will also be able to apply the theories learnt to practical situations on board ship as part of your training programme.

You will be encouraged to make judgements about sustainability in the workplace when considering material selection, disposable items and recycling.

Your employability will be enhanced by gaining a wider knowledge in thermodynamics, problem solving and relating theory to practice.

By the end of this unit you will be expected to sit an assessment covering all the learning outcomes where you will be tested on the concepts and theorems that you have studied. The formal assessment for this unit will normally consist of a single assessment paper lasting no more than two and a half hours. The assessment will be conducted under closed-book conditions in which you will not be allowed to take notes or textbooks 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 contribute to the graded unit for learners studying towards and SQA Advanced Certificate or SQA Advanced Diploma in Marine Engineering, in addition learners will be able to develop the core skills of numeracy, literacy, problem solving as well as being able to present data in a graphical format.

In all outcomes each of the assessments requires the learner to be able to solve problems involving statics. This will give the learner the opportunity to develop the component ‘Using Number’ of the Core Skill Numeracy at SCQF level 6. The specific core skill elements that the learner will have to complete are ‘Work confidently to solve a numerical problem’ and ‘Carry out a number of sustained, complex calculations’.

The assessment of this unit may also contribute towards the component ‘Written Communication (writing)’ of the Core Skill Communication at SCQF level 6. Learners may have to structure their responses, which could include varying structure and presenting essential information in a logical manner. The specific core skill elements that learners may have to complete are ‘Present all essential ideas/information and supporting detail in a logical and effective order’ and ‘Vary sentence structure, paragraphing, and vocabulary to suit the purpose and target audience’.

This unit has the Using Number component of Numeracy and the Critical Thinking component of Problem Solving embedded in it. This means that when you achieve the unit, your core skills profile will also be updated to show you have achieved Using Number at SCQF level 6 and Critical Thinking at SCQF level 5.