Higher National unit specification

General information

Unit title: Marine Engineering: Applied Thermodynamics (SCQF level 8)

Unit code: HJ49 35

Superclass: XQ

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Source: Scottish Qualifications Authority

Version: 02

Unit purpose

This unit is designed to enable learners to further develop the knowledge and understanding required to apply the basic principles of heat engines and fluid dynamics to the solution of problems within Marine Engineering systems. The unit will also provide the learner with a base from which future advanced work in Marine Engineering may be undertaken.

Outcomes

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

1 Analyse the use of multistage reciprocating air compressors
2 Apply the concept of reverse heat engine to refrigeration and recognise the properties of common refrigerants
3 Determine the efficiency of steam plant and power from a velocity and a pressure compound steam turbine
4 Solve problems involving fluid mechanics in pipes, pumps, meters and jets.

Credit points and level

1.5 Higher National unit credits at SCQF level 8: (12 SCQF credit points at SCQF level 8)

Recommended entry to the unit

Entry is at the discretion of the centre however it would be an advantage if learners had a knowledge and understanding of thermodynamics. This can be evidenced by possession of the following unit: *Marine Engineering: Heat Engine Principles* and *Marine Engineering: Auxiliary Systems.* The learners should also have a minimum of a level 6 mathematics or equivalent.

Higher National unit specification: General information (cont.)

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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

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 **(http://www.sqa.org.uk/sqa/46233.2769.html)**.

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**.

Higher National 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

Analyse the use of multistage reciprocating air compressors.

Knowledge and/or Skills

- P-V diagrams to describe ideal and actual cycles for multistage compression.
- Effect of intercooling between stages by calculating heat transfer during compression and cooling.
- Work transfer for ideal and actual cycles including clearance for multistage compression.
- Isothermal efficiency.
- Indicated and input power requirements.

Outcome 2

Apply the concept of reverse heat engine to refrigeration and recognise the properties of common refrigerants.

Knowledge and/or Skills

- Concept of entropy to refrigeration using tables and formulae.
- Vapour compression cycles and reversed Carnot cycle using p-H and T-S diagrams.
- Effects of superheating and undercooling and describe the effects using p-H and T-S diagrams.
- COP of actual plant and compare to COP of reversed Carnot cycle.
- Use of intermediate cooling and evaluate the application of intermediate cooling by flash chamber.

Higher National unit specification: Statement of standards (cont)

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Outcome 3

Determine the efficiency of steam plant and power from a velocity and a pressure compound steam turbine.

Knowledge and/or Skills

- Heat energy distribution in a boiler and compile a heat balance account.
- Thermal efficiency
- H-S and T-S charts to evaluate and analyse the basic Carnot and Rankine cycles including improvements from superheating, reheating and feedheating.
- Steady flow energy equation to steam nozzles to calculate throat and exit velocities.
- Reasons for change of nozzle form and convergent and convergent/divergent sections.
- Blade velocity diagrams for impulse and reaction turbines, kinetic and leaving losses.
- Stage power, stage efficiency and stage axial thrust for a velocity and pressure compounded turbines and the number of stages from given steam conditions for a reaction turbine.

Outcome 4

Solve problems involving fluid mechanics in pipes, pumps, meters and jets.

Knowledge and/or Skills

- Flow velocities and pressures in parallel and tapering pipe work systems and Bernoulli's equation.
- Venturi meters.
- Forces on pipe bends.
- Motion of hydraulic jets in relation to projectile theory.
- Power for centrifugal pumps and evaluate performance.

Evidence Requirements for this unit

Written and/or oral evidence for all four Outcomes should be combined together which learners should sit at one single assessment event lasting no more than two and a half hours. The assessment should be conducted under controlled, supervised conditions and should be under closed-book conditions and as such learners should not be allowed to bring any textbooks, handouts or notes to the assessment. Learners will be permitted to use scientific calculators during the assessment.

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.

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.

Outcome 1

Evidence for the Knowledge and/or Skills items in Outcome 1 should be provided on a sample basis. Written and/or oral evidence on a sample **two out of five** Knowledge and/or Skills should be provided in any assessment of this Outcome

In order to ensure that learners will not be able to foresee what items they will be assessed on, a different sample of two out of five Knowledge and/or Skills items are required each time the unit 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 the learner is able to:

- use p-V diagrams to describe and evaluate the operation of intercooled, multistage compressors.
- calculate heat transfer during compression and cooling and evaluate the effect of intercooling.
- calculate the work transfer for multistage compression cycles including clearance volume.
- calculate the isothermal efficiency.
- solve problems relating to work and power of intercooled, multistage compressors.

Outcome 2

Evidence for the Knowledge and/or Skills items in Outcome 2 should be provided on a sample basis. Written and/or oral evidence on a sample of **two out of five** Knowledge and/or Skills should be provided in any assessment of this Outcome

In order to ensure that learners will not be able to foresee what items they will be assessed on, a different sample of two from five Knowledge and/or Skills items are required each time the unit 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 the learner is able to:

- evaluate refrigeration cycles, employing the concept of entropy, using formulae and tables of common refrigerants used in the marine industry
- use p-H, T-S diagrams to describe vapour compression refrigeration cycles including undercooling and superheating
- calculate the effects of undercooling and superheating on a vapour compression refrigeration cycle
- calculate COP of an actual vapour compression cycle and compare to the COP of the reverse Carnot cycle
- describe intermediate cooling and calculate the effect of applying intermediate cooling by flash chamber

Outcome 3

Evidence for the Knowledge and/or Skills items in Outcome 3 should be provided on a sample basis. Written and/or oral evidence on a sample of four out of nine Knowledge and/or Skills should be provided in any assessment of this Outcome.

In order to ensure that learners will not be able to foresee what items they will be questioned on, a different sample of four from nine Knowledge and/or Skills items are required each time the unit 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 the learner is able to:

- calculate the heat energy distribution in a boiler and compile a heat balance account.
- evaluate the thermal efficiency of basic steam cycles.
- demonstrate the use of H-S and T-S charts and tables to evaluate basic cycles including superheating, reheating, feedheating.
- calculate throat and exit velocities of steam nozzles by applying the steady flow energy equation.
- explain nozzle form and reasons for change of section.
- evaluate impulse and reaction turbines by constructing blade velocity diagrams
- calculate kinetic and leaving losses for turbines.
- calculate stage power, stage efficiency and stage axial thrust for a velocity and a pressure compounded turbine.
- calculate the number of stages from given steam conditions for a reaction turbine.

Higher National unit specification: Statement of standards (cont)

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Outcome 4

Evidence for the Knowledge and/or Skills items in Outcome 4 should be provided on a sample basis. Written and/or oral evidence on a sample of two out of five Knowledge and/or Skills should be provided in any assessment of this Outcome.

In order to ensure that learners 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.

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 the learner is able to:

- explain the term venturi meter and solve a problem for either a parallel or tapering pipe which includes a venturi meter. The pipe work can be either, horizontal, vertical or inclined. The effect of friction is to be included in the problem.
- explain and solve a problem which calculates the resultant force on a pipe bend due to change of momentum.
- explain and solve a problem that calculates the reaction force of a hydraulic jet.
- explain and solve a problem related to the impact of a jet on a flat plate which is positioned either perpendicularly or at an incline to the jet.
- explain the principles of operation of a centrifugal pump *and* solve a problem relating to a pump impeller for a single stage centrifugal pump which includes, speed, blade angles, capacity, efficiency and power.

Higher National unit Support Notes

Unit title: Marine Engineering: Applied Thermodynamics (SCQF level 8)

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 60 hours.

Guidance on the content and context for this unit

This unit has been written in order to allow learners to develop skills, knowledge and understanding of the principles of Applied Thermodynamics in the following areas:

1 Analyse the use of multistage reciprocating air compressors.
2 Apply the concept of reverse heat engine to refrigeration and recognise the properties of common refrigerants.
3 Determine the efficiency of steam plant and power from a velocity and a pressure compound steam turbine.
4 Solve problems involving fluid mechanics in pipes, pumps, meters and jets.

In designing this unit, the unit writer has identified the range of topics expected to be covered by lecturers. The writer has also given 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 learners in this unit.

1 Analyse the use of multistage reciprocating air compressors. (10 hours)

In this section it is expected that questions set should relate to real life examples, using marine terminology, as found aboard ship. The compressors considered should be of no more than three stages and may use water or air cooled intercoolers. The effects of excessive clearance volume, changes in ambient temperature and pressure, fouling of intercoolers should also be considered.

Higher National unit Support Notes (cont)

Unit title: Marine Engineering: Applied Thermodynamics (SCQF level 8)

2 Apply the concept of reverse heat engine to refrigeration and recognise the properties of common refrigerants. (10 hours)

In this section it is expected that questions set should relate to a vapour compression refrigeration plant including superheating, undercooling and intercooling using the concept of entropy. PH and TS diagrams should be used to show the condition of the plant at the main points of the cycle. Thermodynamic property tables should be used to determine the condition of the refrigerants; some interpolation should be included but must not be excessive.

3 Determine the efficiency of steam plant and power from a velocity and a pressure compound steam turbine. (18 hours)

In this section it is expected that questions set should relate to real life examples, using marine terminology, as found aboard ship and should involve the use of thermodynamic property tables and charts to determine the properties of water and steam in the wet, saturated and superheated states. Questions on boiler heat balance and steam cycles should reflect practical operations. Questions relating to turbines should include velocity and pressure compounding.

4 Solve problems involving fluid mechanics in pipes, pumps, meters and jets. (22 hours)

In this section it is expected that questions set should relate to real life examples, using marine terminology, as found on board ship and questions involving flows of fluids through tapering and parallel pipes with and without friction losses. Venturi metres in various positions along with pipe bends and valves should be analysed. Questions relating to centrifugal pumps should include flows through the impeller, blade angle impeller speed, work done and efficiency. Ventilation ducts should be considered in terms of controlling air flow.

Guidance on approaches to 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 learners 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 and fluid mechanics 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 this 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 learners to practice what they have learnt through appropriate formative assessments.

Higher National unit Support Notes (cont)

Unit title: Marine Engineering: Applied Thermodynamics (SCQF level 8)

Guidance on approaches to assessment of this unit

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.

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.

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. Assessment should be conducted under controlled, 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. Learners will be permitted to use scientific calculators during the assessment.

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

Throughout this unit learners 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 2 and 3 learners will also be required to interpret complex tabulated and graphical information again 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 learners require to interpret and work through will also develop the Critical Thinking component of Problem Solving, at SCQF level 6. This will allow learners 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 learners may have the opportunity to develop Written Communication of the Core Skill Communication at SCQF level 6. The specific Core Skill elements that the learner 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’.

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 refrigerant 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 and machinery components.

This unit has the Using Number component of Numeracy 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.

History of changes to unit

Version	Description of change	Date
02	Core Skills component Using Number at SCQF level 6 embedded.	01/06/17

General information for learners

Unit title: Marine Engineering: Applied Thermodynamics (SCQF level 8)

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 further develop knowledge, skills and understanding in Marine Engineering Applied Thermodynamics principles and concepts.

This unit will also provide you with an opportunity to study the theoretical and practical operating cycles for multistage air compressors and refrigeration plants.

You will also learn to evaluate steam plant by analysing the boiler, turbine and steam cycle.

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 carrying out practical experiments.

The formal assessment for this unit may 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 consist of three Outcomes that you will study:

1 Analyse the use of multistage reciprocating air compressors.
2 Apply the concept of reverse heat engine to refrigeration and recognise the properties of common refrigerants.
3 Determine the efficiency of steam plant and power from a velocity and a pressure compound steam turbine.
4 Solve problems involving fluid mechanics in pipes, pumps, meters and jets.

Throughout this unit you are required to perform calculations, manage formulae and equations which will give you the opportunity to develop a component of the Core Skill of Numeracy at SCQF level 6. You will also solve problems in assessments which will give you the opportunity to develop the Critical Thinking component of Problem Solving, at SCQF level 6. In addition in the answering of assessment work you may have the opportunity to develop a component of Communication at SCQF level 6.

This unit has the Using Number component of Numeracy 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.