Higher National Unit specification

General information for centres

Unit title: Marine Engineering: Auxiliary Thermodynamic Principles

Unit code: F90T 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 auxiliary systems. The Unit will 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 Solve problems on and explain the use of single stage reciprocating air compressors.
2 Solve problems on the properties of water and steam.
3 Solve problems on and determine the operation of single stage steam turbines.
4 Solve problems on and explain the operation of a vapour compression refrigeration plant.

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 Skills of *Numeracy*, *Problem Solving* and *Communication* 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: Auxiliary Thermodynamic Principles

Unit code: F90T 34

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

Solve problems on and explain the use of single stage reciprocating air compressors.

Knowledge and/or skills

- Ideal p — V diagram for a compressor with clearance volume.
- Effects of clearance volume.
- 'Free air' delivery for an air compressor.
- Volumetric efficiency based on 'free air' and actual air conditions.
- Work input.
- Mechanical efficiency.

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 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 four out of six 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:

- Draw process diagrams and explain the effects of change in clearance volume and compression index.
- Explain the effects of excessive or insufficient clearance volume.
- Calculate free air delivery.
- Calculate volumetric efficiency.
- Calculate work input
- Calculate mechanical efficiency.

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 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.

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: Auxiliary Thermodynamic Principles

Outcome 2

Solve problems on the properties of water and steam.

Knowledge and/or skills

- Pressure enthalpy diagrams
- Differentiate between gas, perfect gas and vapour
- Determine the work transfer of pumping a fluid under constant pressure.
- Changes in enthalpy and internal energy
- Determine the final condition of a vapour after throttling.
- Boiler efficiency
- Equivalent evaporation
- Determine the change in boiler water density with intermittent and continuous blowdown.

Evidence requirements

Evidence for the knowledge and/or skills items in Outcome 2 will be provided on a sample basis. 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 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 five from 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:

- Draw pressure~enthalpy diagrams.
- Use thermodynamic property tables to determine the specific enthalpy, internal energy and specific volume for wet, dry-saturated or superheated vapours.
- Calculate work transfer of pumping a fluid under constant pressure.
- Calculate changes in enthalpy and internal energy.
- Calculate the condition of steam from given data obtained from separating and throttling calorimeter.
- Calculate boiler efficiency.
- Calculate equivalent evaporation.
- Calculate the change in boiler density due to blowdown.

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 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.

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: Auxiliary Thermodynamic Principles

Outcome 3

Solve problems on and determine the operation of single stage steam turbines.

Knowledge and/or skills

- Draw vector diagrams for inlet and outlet steam velocities for single stage impulse and reaction turbines
- Change in K.E. and enthalpy through a nozzle.
- Power developed in a single stage impulse turbine.
- Degree of reaction and the power developed in a reaction turbine pair.
- The axial force acting on a turbine blade.

Evidence requirements

Evidence for the knowledge and/or skills items in Outcome 3 will be provided on a sample basis. 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 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 three 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:

- Sketch combined vector diagrams for single stage impulse or reaction turbine.
- Calculate change in K.E. and enthalpy through a nozzle.
- Determine the power developed in a single stage impulse turbine.
- Determine the degree of reaction and power developed in a reaction turbine pair.
- Calculate the axial force acting on a turbine blade.

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 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.
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.

Outcome 4

Solve problems on and explain the operation of a vapour compression refrigeration plant.

Knowledge and/or skills

- Operation of the principle components of a vapour compression refrigeration system.
- p-H diagram to describe the state of the refrigerant cycle.
- Use property tables to determine the specific enthalpy and specific volume of wet, dry and superheated refrigerants.
- Work transfer during adiabatic compression
- Coefficient of performance and capacity

Evidence requirements

Evidence for the knowledge and/or skills items in Outcome 4 will be provided on a sample basis. 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 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 three 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:

- Identify and explain the operation of the principle components of the refrigeration circuit.
- Use p~H diagrams to explain the refrigeration cycle.
- Use property tables to determine enthalpy and specific volume for refrigerants in different states.
- Calculate work transfer during adiabatic compression.
- Calculate co-efficient of performance and capacity.

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 should derive 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 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.

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. This single assessment paper could be taken at a single assessment event lasting two hours and carried out under supervised, controlled conditions.

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: F90T 34

Unit title: Marine Engineering: Auxiliary Thermodynamic Principles

Superclass category: XQ

Original date of publication: August 2010

Version: 01

History of changes:

Version	Description of change	Date

Source: SQA

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of Higher National qualifications.

Additional copies of this Unit specification can be purchased from the Scottish Qualifications

Authority. Please contact the Customer Contact Centre for further details, telephone 0845 279 1000.

Higher National Unit specification: support notes

Unit title: Marine Engineering: Auxiliary Thermodynamic 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 Solve problems on and explain the use of single stage reciprocating air compressors.
2 Solve problems on the properties of water and steam.
3 Solve problems on and determine the operation of single stage steam turbines.
4 Solve problems on and explain the operation of a vapour compression refrigeration plant.

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 candidates in this Unit.

1 Solve problems on and explain the use of single stage reciprocating air compressors. (6 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 excessive clearance volume, changes in ambient temperature and pressure.

2 Solve problems on the properties of water and steam. (14 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 efficiency and water density should reflect practical operations. Changes in boiler water density should include no blowdown, intermittent blowdown and continuous blowdown.

3 Solve problems on and determine the operation of single stage steam turbines. (12 Hours)

In this section it is expected that questions set should relate single stage impulse turbines and reaction turbine pair, where practical, questions could be answered by use of scale vector diagrams or calculation.

4 Solve problems on and explain the operation of a vapour compression refrigeration plant. (8 Hours)

In this section it is expected that questions set should relate to a basic vapour compression refrigeration plant. pH diagrams should be used to show the condition of the plant at the main points of the cycle and include superheat and undercooling. Thermodynamic property tables should be used to determine the enthalpy and specific volume of wet, dry and superheated refrigerants without interpolation.

Higher National Unit specification: support notes (cont)

Unit title: Marine Engineering: Auxiliary Thermodynamic 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 core skill of *Numeracy* at SCQF level 6. In Outcome 2 and 4 candidates 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 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'.

Higher National Unit specification: support notes (cont)

Unit title: Marine Engineering: Auxiliary Thermodynamic 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: Auxiliary Thermodynamic Principles

This Unit has been designed to allow you to develop knowledge, skills and understanding in thermodynamic principles and concepts as used in auxiliary systems in Marine Engineering.

This Unit will also allow you the opportunity to develop the necessary knowledge and skills to evaluate the operation of air compressors, refrigeration systems and steam turbines.

You will also learn to apply thermodynamic theory to actual 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 four Outcomes that you will study:

1 Solve problems on and explain the use of single stage reciprocating air compressors.
2 Solve problems on the properties of water and steam.
3 Solve problems on and determine the operation of single stage steam turbines.
4 Solve problems on and explain the operation of a vapour compression refrigeration plant.