Higher National Unit specification

General information for centres

Unit title: Marine Engineering: Electrical Motors and Generators

Unit code: F90X 34

Unit purpose: This Unit is designed to enable candidates to develop knowledge and understanding of marine power generation and its utilisation. The Unit will also develop the application of magnetic theory to its application in machine theory. The candidate's understanding of three phase concepts will also be applied to the understanding of a.c. machines.

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

1 Explain and solve problems on three-phase circuits.
2 Explain the principles of and solve problems on magnetism and electromagnetic induction.
3 Explain the action of generators.
4 Explain and solve problems on the action of motors.

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: Access to this Unit is at the discretion of the centre. However, it would be benefit the candidates to have a knowledge and understanding of Mathematics and/or Physics at SCQF level 6 or a National Certificate in Marine Engineering at SCQF level 6.

Core Skills: There are opportunities to develop the Core Skills of *Numeracy*, *Working with Others* and Communication at SQCF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Context for delivery: As 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: Each of the Outcomes may be assessed separately or a combined assessment may be used. It is anticipated that assignment work and formal tests will be used to assess the Outcomes.

Higher National Unit specification: statement of standards

Unit title: Marine Engineering: Electrical Motors and Generators

Unit code: F90X 34

Outcome 1

Explain and solve problems on three-phase circuits.

Knowledge and/or skills

- Balanced star and delta connected loads.
- Power factor.
- Phasor diagrams.
- Unbalanced loads.
- Marine three phase systems.

Evidence Requirements

Evidence for the knowledge and/or skills items in Outcome 1 should be provided on a sample basis. 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, **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 out of 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:

- Calculate line and phase voltages and currents for balanced star and delta connected loads.
- Calculate power factor.
- Draw phasor diagrams for balanced three phase loads.
- Calculate current in the neutral wire of an unbalanced load supplied by three phase, four wire system.
- Explain Marine three phase systems.

Where calculations are performed the candidate must:

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

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.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Electrical Motors and Generators

Assessment guidelines

The assessment of this Outcome can 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 or it may be assessed separately.

Outcome 2

Explain the principles of and solve problems on magnetism and electromagnetic induction.

Knowledge and/or skills

- Non- magnetic and ferromagnetic materials
- Non-composite magnetic circuits
- Composite magnetic circuits
- Current carrying conductor
- Electro- motive- force in a coil
- Self and mutual inductance
- Electro motive force in a conductor

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 **four out of seven** of the knowledge and skills items listed in the Outcome. In any assessment of this Outcome, both knowledge and/or skills items should be sampled.

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 answer **four out of the seven** Evidence Requirements below:

- Draw B-H curves for non-magnetic and one ferromagnetic material
- Solve a problem on simple non-composite magnetic circuits, including the use of graphs.
- Solve a problem on composite magnetic circuits which include air gaps and the effect of fringing and leakage.
- Calculate the force exerted on a current carrying conductor.
- Calculate the magnitude of the electro-motive-force (e.m.f.) generated in a coil.
- Solve a problem related to self and mutual inductance.
- Calculate the magnitude of the induced electro-motive-force(e.m.f..) in a conductor using the equation:

  e = Blv volts where B is the magnetic flux density, l is the length of the conductor and v is the rate at which the conductor is moved through the magnetic field.

Where calculations are performed the candidate must:

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

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 may be combined together with that for Outcomes 1 and 3 to form a single assessment paper, details of which are given under the Evidence Requirements for Outcome 4. It may also be assessed separately.

Outcome 3

Explain the action of generators.

Knowledge and/or skills

- Constructions and connections of a.c. synchronous generators
- Excitation methods
- Full load current and rotor speed
- Voltage and frequency in a.c. synchronous generators.
- Synchronising using lamps, synchroscope and load sharing
- Sychronising and load sharing
- Automatic voltage regulators for a.c. generators
- Failure of automatic voltage regulators
- Causes of failures
- Motoring and its effects
- Preference trips
- Operation of a preference trip
- Insulated and earthed neutral systems
- Operation of reverse power relays
- Earth fault detection
- Methods of protection for a.c. synchronous generators

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, **five out of sixteen** knowledge and/or skills items should be sampled.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Electrical Motors and Generators

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 sixteen 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 the construction and connections of a.c. synchronous generators.
- Explain excitation methods.
- Calculate full load current and rotor speed.
- Explain and solve a problem on the control of voltage and frequency in a.c. synchronous generators.
- Explain synchronising using lamps and synchroscope, and load sharing.
- Solve a problem related to synchronising and load sharing.
- Explain two reasons for the requirements for automatic voltage regulators for a.c. generators.
- Explain the effect of, and state causes for, failure of automatic voltage regulator.
- Explain the effect of two of the following failures: short circuit, loss of excitation, loss of residual magnetism, overload.
- Explain what is meant by motoring and its effects.
- Explain the need for preference trips.
- Explain, with the aid of a schematic diagram, the operation of a preference trip.
- Explain the operation and need for a reverse power relay.
- State the two advantages and two disadvantages of insulated neutral systems and earthed neutral systems for marine a.c. generators.
- Explain, with the aid of sketches, how earth faults are detected for single phase and three phase supplies.
- Explain two methods of protection for a.c. synchronous generators from the following:
- short circuit, over current, under voltage, earth faults, temperature extremes.

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 derives from the application of the formula and correct application of the principles of the calculation.

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 may 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. It may also be assessed separately.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Electrical Motors and Generators

Outcome 4

Explain and solve problems on the action of motors.

Knowledge and/or skills

- Principles and characteristics of induction motors
- Production of torque
- Slip
- Slip formula
- Torque/speed characteristic
- Rotor resistance
- Power flow chart
- Shaft output power and efficiency
- Operation of synchronous motors
- Construction of stators and rotors for induction and synchronous motors
- Speed control
- Phasor diagrams
- Synchronous and induction motors for marine propulsion.

Evidence Requirements

Evidence 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 thirteen** 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 thirteen 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 the principles and characteristics of induction motors.
- Explain how torque is produced.
- Calculate slip.
- Solve a problem involving slip, given number of poles, frequency and motor speed.
- Sketch and label the torque/speed characteristic for a single cage induction motor, indicating starting torque, pull-out torque and synchronous speed.
- Explain how the torque/speed characteristic is affected if the rotor resistance is increased.
- Draw a power flow chart for a three phase induction motor.
- Calculate useful shaft output power and efficiency at full load.
- Explain the principles of synchronous motors.
- Explain the construction of stators and rotors for synchronous motors.
- Explain how speed control is achieved in either an induction motor or a synchronous motor.
- Explain, with the aid of phasor diagrams, how the power factor can be improved.
- Calculate efficiency for either induction or synchronous motor.

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 derives from the application of the formula and correct application of the principles of the calculation.

Evidence should be generated under controlled conditions.

Assessment guidelines

The assessment of this Outcome may 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. Each Outcome may also be assessed separately.

An assignment based assessment may be more applicable for Outcome 4, which would involve candidates producing their assignments under controlled conditions.

Assessments 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.

Administrative Information

Unit code: F90X 34

Unit title: Marine Engineering: Electrical Motors and Generators

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: Electrical Motors and Generators

Guidance on the content and context for this Unit

This Unit could be delivered by a combination of 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 marine electrical/electronic context. The Unit has been designed to incorporate sufficient time to allow lecturers to teach all the core electrical principles in the Unit.

As this Unit provides core electrical/electronic principles that underpin much of the studies in other areas of the HNC and HND Marine Engineering 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 or laboratory work.

Guidance on the delivery and assessment of this Unit

This Unit is best delivered in conjunction with Marine Engineering: Electrical and Electronic Devices (F90W 34).

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.

The assessment of this Unit could be a combined paper for all four Outcomes. This single assessment paper could be taken at a single assessment event lasting two hours and carried out under supervised, controlled 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.

Opportunities for developing Core Skills

There are opportunities to develop the Core Skills of *Numeracy* SQCF level 6 and *Communication* at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

The delivery and assessment of this Unit may contribute towards the component 'Using number' of the Core Skill of *Numeracy* at SQCF 6 in Outcomes 1, 2 and 3. The specific skills required for the component at SQCF 6 include: working confidently with a numerical/statistical concept; deciding on the numerical operations to be carried out; and carrying out complex calculations on a number of sustained calculations. This is likely to fit in with a variety of the topics in all Outcomes (eg solving problems on composite magnetic circuits including air gaps, etc). It is also likely that the component 'Using graphical information' could also be developed in the context of Outcome 2. The specific skills of: analysing and interpreting complex graphical information; and selecting an appropriate form and communicating information can be found in Outcomes 2 and 4 (eg solving problems on non-composite magnetic circuits, including the use of graphs). This Core Skill could be developed here without formal certification.

The component 'Read and understand complex written communication' of the Core Skill of *Communications* SCQF level 6 could also be developed in this Unit in the work for Outcomes 1, 2, 3 or 4. This may be developed in the underpinning knowledge and in formative assessments for these Outcomes in identifying and summarising information, ideas and supporting information. There may also be opportunities to develop the component 'produce well-structured written communication on complex topics' in the formative assessment of these Outcomes. The candidate is required to explain concepts and principles in a logical and effective order and also to use conventions which are effective. Evidence could be obtained for both these components through written essay type formative assessments, particularly in Outcomes 3 and 4. This Core Skill could be developed here without formal certification.

This Unit may allow candidates to complete laboratory work and formative assessment which may allow candidates to develop 'Working co-operatively with others' of the Core Skill '*Working with Others'* at SCQF level 6. Through the candidate's laboratory work and formative assessments this may allow them to develop the specific skills 'Analyse own role and the roles that make up the activity and/or activities and relationship between them' and 'Organise own role to contribute effectively to the activity and/or activities, adapting own role as necessary'.

Open learning

For information on open learning arrangements, please refer to the SQA guide, *Assessment and Quality Assurance of Open and Distance Learning* **(www.sqa.org.uk).**

Although this Unit could be delivered by distance learning, it would require a considerable degree of planning by the centre to ensure the sufficiency and authenticity of candidate evidence. Arrangements would have to be made to ensure that the closed-book test for Outcomes 1, 2, 3 and 4 is delivered in a supervised environment.

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: Electrical Motors and Generators

This Unit has been designed to allow you to develop knowledge, skills and understanding of motors and generators used on board ships.

The Unit will also allow you the opportunity to develop the necessary knowledge and skills to evaluate the operation of motors and generators in marine applications.

You will also learn to apply electrical principles to Marine equipment in order to assess its 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 Electrical 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 may sit this assessment paper at the end of the Unit.