



National Unit Specification: general information

UNIT Engineering: Prime Movers (SCQF level 6)

CODE F5JD 12

SUMMARY

This Unit may form part of a National Qualification Group Award or may be offered on a free standing basis.

The Unit is designed to allow candidates to develop knowledge and understanding of mechanical prime movers. During delivery of the Unit candidates will learn to describe the sequence of operation and the performance of internal combustion (IC) engines. Engine performance will be described in terms of the differences between the pressure-volume (p-V) diagram for Ideal Air Standard cycles and practical p-V diagrams for IC engines. Candidates will also develop the knowledge and understanding to determine key performance parameters for IC engines. They will also develop knowledge of different turbines and their applications as well as learning to explain the fundamental principles of turbine operation in terms of impulse and reaction blading. Candidates will also be provided with an opportunity to investigate a given prime mover system in some depth.

This Unit is suitable for candidates training to be maintenance, mechanical or multi-disciplinary engineering technicians.

OUTCOMES

- 1 Describe the operation and performance of a given IC engine.
- 2 Determine performance parameters for a given IC engine from given data.
- 3 State turbine types and applications and explain the fundamental operation of turbines.
- 4 Investigate the construction, operation and performance of a given mechanical prime mover.

Administrative Information

Superclass: XK

Publication date: March 2009

Source: Scottish Qualifications Authority

Version: 01

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National Unit Specification: general information (cont)

UNIT Engineering: Prime Movers (SCQF level 6)

RECOMMENDED ENTRY

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

- ◆ the NQ Unit Prime Movers at SCQF level 5
- ◆ Standard Grade Physics at credit level
- ◆ Standard Grade Technological Studies at credit level

CREDIT VALUE

1 credit at SCQF level 6 (6 SCQF credit points at SCQF level 6*).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

CORE SKILLS

There is no automatic certification of Core Skills in this Unit.

The Unit provides opportunities for candidates to develop aspects of the following Core Skills:

- ◆ Communication (SCQF level 6)
- ◆ Numeracy (SCQF level 6)
- ◆ Problem Solving (SCQF level 6)
- ◆ Working with Others (SCQF level 5)

These opportunities are highlighted in the Support Notes of this Unit Specification.

National Unit Specification: statement of standards

UNIT Engineering: Prime Movers (SCQF level 6)

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

OUTCOME 1

Describe the operation and performance of a given IC engine.

Performance Criteria

- (a) Describe correctly the function of the main components of an IC engine.
- (b) Describe correctly the sequence of operations of an IC engine.
- (c) Draw correctly the p-V diagram for an Ideal Air Standard cycle for an IC engine.
- (d) Draw correctly a p-V diagram for a practical IC engine.
- (e) Compare correctly the operation of an IC engine in terms of the p-V diagram for the Ideal Air Standard cycle and the p-V diagram for the practical engine.

OUTCOME 2

Determine performance parameters for a given IC engine from given data.

Performance Criteria

- (a) Calculate correctly the work done by a piston in a single acting IC engine.
- (b) Calculate accurately a range of parameters for a given IC engine from given data.
- (c) State correctly the engine speeds at which the efficiencies are a maximum for the given IC engine.

OUTCOME 3

State turbine types and applications and explain the fundamental operation of turbines.

Performance Criteria

- (a) State correctly the names of different types of turbines.
- (b) State correctly applications of different types of turbines.
- (c) Explain correctly, with the aid of suitable diagrams, the difference in construction and principle of operation of impulse and reaction turbines.

National Unit Specification: statement of standards (cont)

UNIT Engineering: Prime Movers (SCQF level 6)

OUTCOME 4

Investigate the construction, operation and performance of a given mechanical prime mover.

Performance Criteria

- (a) Draw clearly an annotated diagram of a given prime mover.
- (b) Describe correctly the principle of operation of the given prime mover.
- (c) State correctly which of Newton's Laws underpins the operation of a given prime mover.
- (e) Evaluate correctly the performance characteristics of a given prime mover.

EVIDENCE REQUIREMENTS FOR THIS UNIT

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

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

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

With regard to Outcome 1

- ◆ candidates must identify the function of four components of an IC engine from the following list: cylinder block, piston, con-rod, crankshaft, cylinder head, inlet and exhaust valves, spark plug (SI only) and fuel injector (CI only)
- ◆ candidates must describe the sequence of operation of a four stroke SI or CI engine

With regard to Outcome 2

- ◆ candidate must calculate the work done by a piston from given data using a formula such as:

Work done by piston = $P a l$ Joules

where P = mean effective pressure in the cylinder, a = area of the piston, l = active bore length

National Unit Specification: statement of standards (cont)

UNIT Engineering: Prime Movers (SCQF level 6)

- ◆ candidates must calculate the following engine parameters.
 - compression ratio
 - indicator power
 - brake power
 - power lost to friction
 - mechanical efficiency
 - thermal efficiency

With regard to Outcome 3

- ◆ candidates must state the name of four turbines from the following list: steam, gas, wind, water (eg Pelton, Francis, Kaplan or Voight), transonic, contra-rotating, statorless, ceramic, shrouded, shroudless, bladeless or any other suitable type
- ◆ candidates must state 1 application of four turbines from the following list: steam, gas, wind, water (eg Pelton, Francis, Kaplan or Voight), transonic, contra-rotating, statorless, ceramic, shrouded, shroudless, bladeless or any other suitable type

With regard to Outcome 4

- ◆ candidate evidence should be between 750 and 1,000 words in length plus diagrams, relevant technical and a list of references
- ◆ candidates should select a prime mover system on the basis of the following factors:
 - vocational requirement
 - local industry requirements
 - career progression
 - personal interest

National Unit Specification: support notes

UNIT Engineering: Prime Movers (SCQF level 6)

This part of the Unit Specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON THE CONTENT AND CONTEXT FOR THIS UNIT

This Unit forms part of the National Qualification Group Award in Mechanical Engineering at SCQF level 6, but may also be offered on a free standing basis.

The aim of this Unit is to allow candidates to develop knowledge and understanding of mechanical prime movers. On successful completion of the Unit candidates will have learnt to describe the sequence of operation and the performance of internal combustion engines. Candidates will also have developed the knowledge and understanding to determine key performance parameters of IC engines. They will also be able to identify different turbines and their applications and be able to explain the fundamental principles of turbine operation in terms of impulse and reaction blading. Candidates will also have completed an investigation of a given prime mover system in some depth.

In Outcome 1 candidates should be introduced to a range of IC engines fuelled by petrol, diesel and suitable commercially available gases. Both four stroke and two stroke engines should be described and the advantages and disadvantages of each discussed. Candidates should learn about the functions of the main components of IC engines and the sequence of operation of engines. Candidates should also be introduced to Ideal Air Standard cycles (eg Otto, Diesel etc) principally to provide a theoretical reference from which the shortcomings of practical engines can be discussed.

In Outcome 2 candidates should be taught how to calculate work done on a piston. Ideally during the delivery of this Outcome candidates should have access to a self contained engine test rig complete with data acquisition software which would allow them to investigate a range of engine performance characteristics. Candidates should be taught the meaning of the test data being generated and use the data to calculate parameters that impact on engine performance characteristics. Sufficient test data should be made available to construct a graph of mechanical and thermal efficiencies versus engine speed and from these graphs maximum efficiencies should be determined.

In Outcome 3 attention should switch from reciprocating to rotary prime movers as candidates considered turbines. Candidates should be taught about the use of turbines in a wide range of engineering applications (eg steam plant, aircraft, generation of renewable energy etc). They should also learn the differences in construction and principle of operation of impulse and reaction turbines. They may also be taught how the principles of both types of blading are combined in many modern turbine designs.

In Outcome 4 candidates are provided with an opportunity to investigate a mechanical prime mover system in some depth. Candidates should examine the construction and principle of operation of the prime mover system. To provide a degree of theoretical underpinning the operation of the prime mover system should be related directly to Newton's Laws. They should also evaluate the performance of the prime mover system in terms of such factors as typical power outputs, speed range, efficiency and suitability for given application(s).

National Unit Specification: support notes (cont)

UNIT Engineering: Prime Movers (SCQF level 6)

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

It is recommended that the Unit is delivered in the same sequence the Outcomes are presented in the National Unit Specification: statement of standards section of the Unit. The Unit may be delivered by a combination of lectures, group work, practical work, computer simulation and industrial visits. The Unit may be delivered in a classroom and/or mechanical laboratory. Candidates should have access to different types of IC engines and sectioned engine assemblies together with laboratory scale turbines. The use of practical working machines to demonstrate the principles involved and provide a visual hands-on experience is recommended. Mechanical laboratory work in which candidates perform tests on engines and turbines is strongly recommended as this greatly enriches the candidate learning experience especially when acquiring test data and investigating the performance characteristics of prime movers. Candidates should be provided with appropriate Health and Safety training before undertaking any laboratory work.

Visits to original equipment manufacturers facilities and industrial and utility installations should be included in Unit delivery where possible to provide candidates with valuable insights into how prime movers are constructed and used in 'real life' industrial applications.

It should be noted that the Internet contains a rich source of information on the construction, principles of operation and applications of various types of engines and turbines. Annotated pictorial diagrams of engine and turbine constructional features and video clips of prime movers in operation can also act as important sources of learning.

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

The Reading Core Skill component at SCQF level 6 may be developed in all four Outcomes while candidates are examining information in paper based and electronic form dealing with such subjects as the terminology, construction, sequence of operation and performance characteristics of prime movers.

The Written Communication Core Skill component at SCQF level 6 may be developed in Outcomes 1, 3 and 4 while candidates provide written technical responses to subjects involving the construction, sequence of operation and performance characteristics of prime movers.

The Using Number Core Skill component at SCQF level 6 may be developed in Outcome 2 while candidates perform calculations involving the performance parameters of IC engines.

The Critical Thinking Core Skills component at SCQF level 6 may be developed in Outcomes 2 and 4 while candidates evaluate the performance characteristics of prime movers.

The Working with Others Core Skill at SCQF level 5 may be developed in Outcomes 2 and 4 while candidates undertake practical laboratory work on IC engines and turbines as they have to interact with their lecturers, support staff and other candidates, for example while sharing laboratory areas, tools and equipment.

National Unit Specification: support notes

UNIT Engineering: Prime Movers (SCQF level 6)

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003)*, *SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

Centres are encouraged to use formative assessment extensively as it plays a particularly important role in allowing candidates to develop a sound knowledge and understanding of such subjects as the construction, sequence of operations and performance characteristics of prime movers.

Outcomes 1, 2 and 3

Outcomes 1, 2 and 3 may be assessed by a single assessment comprising of a suitable balance of short answer, restricted response and structured questions. IC engine test data in Outcome 2 may be obtained from practical tests and/or manufacturers data sheets.

Outcome 4

Outcome 4 may be assessed by an investigation on a given prime mover system. Where resources exist part of this investigation may involve practical laboratory work. Candidate evidence should be in the form of a written report. The exact structure of the report is left to centres to decide but may take the following form:

- ◆ purpose of report
- ◆ constructional details of prime mover system
- ◆ sequence of operation of prime mover system
- ◆ performance characteristics of prime mover system
- ◆ conclusions

Reports may be completed in the candidates own time. Centres should make every reasonable effort to ensure that the report is the candidate's own work. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter. A checklist should be used to record oral evidence of the candidate's knowledge and understanding.

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