

SQA Advanced Unit specification

General information for centres

Unit title: Electrical Motor Drive Systems

Unit code: HT7M 48

Unit purpose: This Unit has been designed to allow candidates to develop a knowledge and understanding of electrical motor drive systems at both a systems level and at individual component level (eg transmission arrangements, electrical protection and starting and braking methods). Candidates will also have an opportunity to consolidate their knowledge of electrical motor drive systems by undertaking an investigation of the reasons for the selection of the component parts in a practical industrial or commercial drive system.

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

1. Outline the factors that influence the choice of a motor to drive a given industrial load.
2. Distinguish different forms of motor to load power transmission systems.
3. Analyse different electrical protection arrangements used with electrical motors.
4. Analyse starting and braking arrangements associated with electric motors.
5. Investigate the selection of motor and ancillary equipment for a given industrial load.

Credit value: 1 SQA Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*)

**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 National 1 to doctorates.*

Recommended prior knowledge and skills: Candidates should have a general knowledge and understanding of electrical motors. This may be evidence by possession of the following SQA Advanced Unit: HT83 47 Electrical Machine Principles. Some knowledge and understanding of the dynamics of rotating systems would also be an advantage. However, entry requirements are at the discretion of the centre.

Core Skills: There may be opportunities to gather evidence towards the following listed Core Skills or Core Skills components in this Unit, although there is no automatic certification of Core Skills or Core Skills components:

- ◆ Written Communication (reading) at SCQF level 6
- ◆ Written Communication (writing) at SCQF level 6
- ◆ Using Graphical Information at SCQF level 6
- ◆ Critical Thinking at SCQF level 6
- ◆ Reviewing and Evaluating at SCQF level 6

SQA Advanced Unit Specification

Context for delivery: This Unit has been developed for the SQA Advanced Diploma in Electrical Engineering. If the Unit is delivered as part of another 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 Unit has two assessments. The first assessment, which covers Outcomes 1 to 4, should be a written test, lasting two hours and should be conducted under supervised, controlled conditions. The second assessment, which covers Outcome 5, should comprise of an assignment involving the investigation of the selection of a motor, transmission system, electrical protection and starting/braking methods for a given industrial or commercial electrical motor drive system. Candidates should submit a report of between 750–1000 words in length and may include diagrams and appendices.

SQA Advanced Unit specification: statement of standards

Unit title: Electrical Motor Drive Systems

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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

Outline the factors that influence the choice of a motor to drive a given industrial load

Knowledge and/or skills

- ◆ block diagram showing the need for power transmission system, electrical protection and starting/braking arrangements
- ◆ speed (eg fixed speed versus variable speed)
- ◆ mechanical load types
- ◆ motor-load matching
- ◆ starting
- ◆ power rating and duty cycle
- ◆ environmental conditions
- ◆ maintenance requirements

Outcome 2

Distinguish different forms of motor to load power transmission systems

Knowledge and/or skills

- ◆ factors influencing choice of power transmission systems (high inertia loads, resonance with natural frequency of system, backlash)
- ◆ flexible couplings
- ◆ chain and sprocket drive
- ◆ pulley and belt drive
- ◆ clutches
- ◆ gearboxes

Outcome 3

Analyse different electrical protection arrangements used with electrical motors.

Knowledge and/or skills

- ◆ need for electrical protection
- ◆ different types of electrical protection (over current, earth leakage)
- ◆ components used in electrical protection systems (fuses, relays, circuit breakers)
- ◆ electrical protection circuitry

Outcome 4

Analyse starting and braking arrangements associated with electrical motors.

Knowledge and/or skills

- ◆ different types of starting arrangements (for both d.c. and a.c. motors)
- ◆ starting circuitry
- ◆ identify factors influencing motor braking choice
- ◆ different types of braking arrangements (regenerative braking, reverse current and d.c. dynamic braking)
- ◆ braking circuitry

Evidence Requirements

Evidence for the knowledge and /or skills in Outcomes 1 to 4 will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that she/he can answer correctly questions based on a sample of the items shown under the knowledge and skills items in all four Outcomes. In any assessment of the Outcomes **five out of eight** knowledge and/or skills items should be sampled from Outcome 1, **four out of six** knowledge and/or skills items from Outcome 2, **three out of four** knowledge and/or skills items from Outcome 3 and **three out of five** knowledge and/or skills items from Outcome 4.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of five out of eight knowledge and/or skills items from Outcome 1, four out of six knowledge and/or skills items from Outcome 2, three out of four knowledge and/or skills items from Outcome 3 and three out of five knowledge and/or skills items from Outcome 4 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 that the candidate is able to:

Outcome 1

- ◆ draw a block diagram to identify the need for power transmission system, electrical protection and starting and braking arrangements for an electric motor – drive system
- ◆ identify the speed requirements of different types of motor – load arrangements
- ◆ identify, with the aid of suitable torque- speed graphs, different types of mechanical loads
- ◆ explain the importance of load matching a motor to its load
- ◆ explain the particular factors that influence motor starting
- ◆ explain the terms power rating and duty cycle
- ◆ explain environmental factors that may impact on the performance of a motor and the ways these are minimised in good motor design
- ◆ explain the importance of allowing access for maintenance when siting a motor–drive system

SQA Advanced Unit Specification

Outcome 2

- ◆ explain the factors that influence the choice of a power transmission system in motor-drive systems
- ◆ explain, with the aid of diagrams, how different types of flexible couplings can be used in motor-drive systems
- ◆ explain, with the aid of a diagram, how a chain and sprocket drive can be used in motor-drive systems
- ◆ explain, with the aid of diagrams, how different types of pulley-belt drives can be used in motor-drive systems
- ◆ explain, with the aid of diagrams, how different types of clutches can be used in motor-drive systems
- ◆ explain how a gearbox is used in motor-drive systems

Outcome 3

- ◆ explain the need for electrical protection
- ◆ explain different types of electrical protection used with a motor-drive system
- ◆ explain, with the aid of suitable diagrams, the constructional features and characteristics of components used in electrical protection systems
- ◆ identify electrical protection circuitry

Outcome 4

- ◆ explain, with the aid of annotated diagrams, at least two types of motor starting arrangements
- ◆ identify starting circuitry
- ◆ explain the factors that influence the choice of braking arrangement in a motor-drive system
- ◆ explain, with the aid of annotated diagrams, at least two types of motor-braking arrangements
- ◆ identify braking circuitry

The assessment for Outcomes 1 to 4 should be combined together to form one assessment paper. This single assessment paper should 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 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 paper may be composed of an appropriate balance of short answer, restricted response and structured questions.

Outcome 5

Investigate the selection of motor and ancillary equipment for a given industrial load.

Knowledge and/or skills

- ◆ choice of motor
- ◆ choice of power transmission system
- ◆ choice of electrical protection
- ◆ choice of starting and braking arrangements

All knowledge and /or skills items in Outcome 5 should be assessed. The evidence should be presented in response to an assignment in which the candidate is set the task of investigating the

SQA Advanced Unit Specification

choice of a suitable motor, transmission system, electrical protection and starting and braking arrangements to match a given load.

A candidate's response can be judged to be satisfactory where the evidence provided is sufficient to meet the requirements for each item by the candidate showing that he/she is able to explain the choice of:

- ◆ motor
- ◆ transmission system
- ◆ electrical protection
- ◆ starting and braking arrangements

The assignment should be based on a real industrial or commercial situation in which a motor is required to drive a load.

Candidates should have access to course notes, relevant textbooks and suppliers' catalogues whilst doing the assignment.

Assessment guidelines

Evidence for this Outcome should be gathered by the candidate preparing a report which covers the four knowledge and skills items for this Outcome. Centres may wish to issue candidates with suitable guidance notes giving advice on the best way to structure their reports. The report should be between 750–1,000 words long and may include diagrams and appendices.

Centres should make every reasonable effort to ensure the assignment solution 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.

Administrative information

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Superclass category:	XJ
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SQA Advanced Unit specification: support notes

Unit title: Electrical Motor Drive Systems

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 their knowledge and understanding in the following areas:

1. outlining the factors that influence the choice of a motor to drive a given industrial load
2. distinguishing different forms of motor to load power transmission systems
3. analysing different electrical protection arrangements used with electrical motors
4. analysing starting and braking arrangements associated with electrical motors
5. investigating the selection of a motor and ancillary equipment for a given industrial load

This Unit has been developed to provide candidates on the SQA Advanced Diploma in Electrical Engineering with a sound knowledge and understanding of the technical factors involved in selecting motor and ancillary equipment (eg power transmission unit, electrical protection and braking). In addition, candidates will also have an opportunity to consolidate this knowledge and understanding by investigating the selection of motor and ancillary equipment for a given industrial load. Electrical Motor Drive Systems is a 1-credit Unit at SCQF Level 8 (8 SCQF credit points at SCQF Level 8). It is included within the mandatory section of the SQA Advanced Diploma in Electrical Engineering.

This Unit has been developed to follow on from the SQA Advanced Certificate Electrical Engineering Unit, Electrical Machine Principles, and it is strongly recommended that candidates have studied that Unit before undertaking this Unit.

In designing this Unit, the writers have identified the range of topics expected to be covered by lecturers. The writers have also given recommendations as to how much time should be spent on each Outcome. This has been done to help lecturers to 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, and because the assessment exemplar pack for this Unit is based on the knowledge and/or skills and list of topics in each of the Outcomes.

A list of topics is given below. Lecturers are advised to study this list of topics in conjunction with the assessment exemplar pack so that they can get a clear indication of the standard of achievement expected of candidates in this Unit.

Outcome 1 (9 hours)

Outline the factors that influence the choice of a motor to drive a given industrial load.

- ◆ block diagram of motor and load system also showing transmission arrangements, electrical protection and starting/braking
- ◆ explanation of block diagram
- ◆ motor speeds – fixed versus variable

SQA Advanced Unit Specification

- ◆ different types of motor load (eg fixed torque versus variable torque [eg fan, pump, compressor])
- ◆ explanation concerning matching motor torque to load torque (use of diagrams to illustrate load matching)
- ◆ explanation of normal and adverse starting conditions (eg high inertia loads, high starting currents, potential serious volt-drops)
- ◆ power rating and relationship to heat losses
- ◆ impact of duty cycle on motor performance
- ◆ explanation of environmental considerations (ingress of materials, ingress of water, cooling arrangements and cooling circuit power, International Electrotechnical Commission (IEC) standards on protection against ingress of foreign bodies)
- ◆ maintenance considerations (eg ease of access for maintenance purpose, demands of maintenance schedule, costs, etc)

Outcome 2 (9 hours)

Distinguish different forms of motor to load power transmission systems.

- ◆ discussion of factors that affect the selection of power transmission systems (eg nature of load – torque demand on motor, resonance with natural frequency of system, backlash, cost)
- ◆ explanation of how the following types of transmission systems can be used with electric motors:
 - flexible couplings
 - chain and sprocket drive
 - pulley and belt drive
 - clutches
 - gearboxes
- ◆ key performance characteristics of these types of transmission system
- ◆ use of manufactures catalogues and Internet to explore different drive types
- ◆ calculations involving the sizing of drives

Outcome 3 (6 hours)

Analyse different electrical protection arrangements in electrical motors.

- ◆ explanation for the need for electrical protection in a motor drive system
- ◆ identification of over current and earth leakage as the main forms of electrical protection
- ◆ examination of protection components, their main constructional features and key performance characteristics as used in electrical protection systems (eg fuses, relays and circuit), use of manufactures' catalogues and Internet to support this examination
- ◆ examination of different electrical protection circuitry

Outcome 4 (6 hours)

Analyse starting and braking arrangements associated with electric motors.

- ◆ explanation of different types of starting methods used with d.c. and a.c. motors
- ◆ examination of different starting circuitry
- ◆ identify factors influencing choice of braking method in terms of performance and cost
- ◆ explanation of different braking methods used with d.c. and a.c. motors (regenerative, reverse current and d.c. dynamic braking)
- ◆ examination of different braking circuitry

Written Test: 2 hours

Outcome 5 (8 hours)

Investigate the selection of motor and ancillary equipment for a given industrial load.

- ◆ The content for this Outcome is fully specified under Outcome 5 in the SQA Advanced Unit specification: statement of standards section.

Guidance on the delivery and assessment of this Unit

This Unit has been designed to initially take a systems approach to electrical motor drive systems via a block diagram approach. Individual parts of the system (eg transmission arrangements, electrical protection and starting and braking) are then analysed in greater depth. The operation and performance characteristics of electrical motors are not considered in this Unit as they are dealt with in some detail in the Unit, Electrical Machines Principles. Centres delivering this Unit are strongly encouraged to allow candidates to view as many electric motor drive system component parts as possible. This may be achieved through the parts of motor drive systems being available at the centre or by visits to appropriate industrial or commercial premises. Good charts and other visual aids showing complete and disassembled parts of various elements of electrical motor drive systems will also be a good aid to candidate learning. The Internet provides a rich source of information on transmission systems, electrical protection and starting and braking components and candidates should be actively encouraged to explore sites which contain helpful information. Likewise manufacturers' catalogues and datasheets also contain useful sources of information on motor drive system components.

Information on evidence requirements and assessment guidelines are given after Outcomes 4 and 5 in the SQA Advanced Unit specification: statement of standards section. The written assessment paper should take place after Outcomes 1 to 4 have been completed and the assignment would normally be undertaken following the written test.

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of online support. However, with regards to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that assessment, whether done at a single or multiple events, was conducted under controlled, supervised conditions.

To keep administrative arrangements to a minimum, it is recommended that for distance learning candidates the assessment paper is taken at a single assessment event.

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.

General information for candidates

Unit title: Electrical Motor Drive Systems

It is important to recognise that an electrical motor is normally part of an overall system which drives a given load. The system will also contain some form of mechanical transmission arrangement (eg a coupling, pulley or gearbox) to transmit the motor's torque to the load. The system will have electrical protection to protect the motor against adverse electrical and mechanical conditions and both starting and braking arrangements to start and stop the motor.

In this Unit you will first consider electrical motor drive systems at a system's level and then you will look in greater depth at individual parts of the system (eg transmission systems, electrical protection and starting and braking methods). You will also be provided with an opportunity to consolidate your knowledge and understanding of motor drive systems by undertaking an investigation of motor and ancillary equipment for a given industrial load.

There are plenty of good learning materials available both in paper format and via the Internet on motor drive systems and the component parts of these systems. Your lecturer is likely to strongly encourage you to explore manufacturers' catalogues, datasheets and investigate Internet sites to find out more about motor drive systems and their component parts.

Assessment for this Unit will comprise of a two hour written test following the delivery of Outcomes 1 to 4 followed by an assignment in which you will have an opportunity to investigate the selection of motor, transmission system, electrical protection and starting and braking methods in an industrial or commercial electrical motor drive system.