Higher National Unit Specification

General information for centres

Unit title: Electrical Motors and Motor Starting

Unit code: DV9M 34

Unit purpose: This Unit has been developed to provide candidates with an opportunity to develop their knowledge and understanding of the construction, operation, performance characteristics and maintenance requirements of motors commonly used in domestic and industrial applications. The motors considered in the Unit are: universal, single phase motors and three phase motors. Candidates will also learn about normal starting methods used with three-phase induction motors and will also be required to select a starter for a given three phase induction motor application. This Unit has been written particularly for those candidates studying motors at an Advanced Engineering Craft level.

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

1 Explain the construction, principle of operation and characteristics of a Universal Motor.
2 Explain the construction, principle of operation and characteristics of Single Phase Induction Motors.
3 Explain the construction, principle of operation and performance characteristics of Three Phase Induction Motors.
4 Explain and select Three-Phase Induction Motor Starting Methods.

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: Entry is at the discretion of the centre however candidates should have a broad knowledge and understanding of electrical principles. This may be evidence by possession of the following HN unit: Electrical Engineering Principles 1.

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

Using Graphical Information	SCQF 5
Critical Thinking	SCQF 6
Written Communication	SCQF 6

General information for centres (cont)

Context for delivery: This Unit has been developed for the Advanced Certificate in Electrical Engineering / HNC Engineering Practice awards. 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 three assessments. The first assessment, which covers Outcomes 1 and 2, must be a closed book assessment paper lasting one hour and fifteen minutes which must be conducted under supervised, controlled conditions. The second assessment, which covers Outcome 3 and the first six bullet points in Outcome 4, must also comprise of a closed book assessment paper lasting one hour and fifteen minutes which must be conducted under supervised, controlled conditions. Candidates must not be allowed to bring text books, handouts, notes etc into either of these assessments. The third assessment, which covers bullet point 7 in Outcome 4, must consist of an assignment in which a candidate selects a suitable starter for a three-phase induction motor and justifies its selection. Candidate evidence should be presented in the form of a short report.

Higher National Unit specification: statement of standards

Unit title: Electrical Motors and Motor Starting

Unit code: DV9M 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

Explain the construction, principles of operation and characteristics of a Universal Motor.

Knowledge and/or skills

- Constructional features
- Principle of Operation
- Performance Characteristics
- Typical Applications
- Maintenance Requirements

Outcome 2

Explain the construction, principle of operation and characteristics of Single Phase Induction Motors.

Knowledge and/or skills

- Creation of a rotation magnetic field from single phase supply
- Constructional features and principle of operation of main types of single-phase motors
- Performance characteristics of principal motor types
- Typical applications
- Maintenance Requirements

Evidence Requirements

Evidence for the knowledge and /or skills in Outcomes 1 and 2 will be provided on a sample basis. The evidence may be presented in response 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/or skills items in both Outcomes. In any assessment of the Outcomes **three out of five** knowledge and/or skills items should be sampled from Outcome 1 and **three out of five** knowledge and/or skills items should be sampled from Outcome 2.

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 from Outcome 1, and three out of five knowledge and/or skills items from Outcome 2 are required each time the Unit is assessed. Candidates must provide a satisfactory response to all sampled items.

Higher National Unit specification: statement of standards (cont)

Unit title: Electrical Motors and Motor Starting

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

- explain the constructional features of a Universal Motor
- explain the principle of operation of a Universal Motor
- outline the key performance characteristics of a Universal Motor
- state two applications of a Universal Motor
- explain the maintenance requirements of a Universal Motor

Outcome 2

- explain how a rotating magnetic field can be produced from a single-phase supply
- explain, with aid of diagrams, the main constructional features and principle of operation of at least two of the main types of single phase motors (split phase, capacitor start, capacitor start - capacitor run, shaded pole)
- differentiate the performance characteristic of principal motor types
- explain one application of principal motor types
- explain the maintenance requirements of principal motor types

The assessment for Outcomes 1 and 2 must be combined together to form one assessment paper. This single assessment paper must be taken at a single assessment event lasting one hour and fifteen minutes and must be carried out under supervised, controlled conditions. Assessment must be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment.

Assessment guidelines

The assessment paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

Outcome 3

Explain the construction, principle of operation and performance characteristics of Three Phase Induction Motors.

Knowledge and/or skills

- Constructional features of squirrel cage and wound rotor machines
- Principle of operation
- Synchronous speed and slip
- Performance characteristics
- Typical applications
- Maintenance Requirements

Higher National Unit specification: statement of standards (cont)

Unit title: Electrical Motors and Motor Starting

Outcome 4

Explain and select Three Phase Induction Motor Starting Methods

Knowledge and/or skills

- Direct-on-Line
- Star-Delta
- Auto-Transformer
- Rotor Resistance
- Soft-starting
- Comparison of starting methods
- Starter Selection

Evidence Requirements

Evidence for the knowledge and/or skills in Outcomes 3 and 4 will be provided on a sample basis. The evidence may be presented in response 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 both Outcomes. In any assessment of the Outcomes **four out of six** knowledge and/or skills items should be sampled from Outcome 3 and any **three out of the first six** knowledge and skills items should be sampled from Outcome 4. **Bullet point 7** in Outcome 4 on starter selection should always be assessed.

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 from Outcome 3, and any three out of the first six knowledge and/or skills items from Outcome 4 are required each time the Unit is assessed. Bullet point 7 should always be sampled.

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 3

- identify the main constructional features of squirrel cage and wound rotor induction motors
- explain the principle of operation of three phase induction motor
  explain the terms synchronous speed and slip and perform two calculations involving these two quantities
- explain, with the aid of torque — slip curves, the performance characteristics of three-phase induction motors
- explain two applications of three-phase induction motors
- explain the maintenance requirements of three phase induction motors

Higher National Unit specification: statement of standards (cont)

Unit title: Electrical Motors and Motor Starting

Outcome 4

- explain, with the aid of a circuit diagram, the principle of operation of Direct-on-Line starting
- explain, with the aid of a circuit diagram, the principle of operation of Star-Delta starting
- explain, with the aid of a circuit diagram, the principle of operation of Auto-Transformer starting
- explain, with the aid of a circuit diagram, the principle of operation of Rotor Resistance starting
- explain, with the aid of a diagram, the principle of operation of soft starting
- compare, in table format, the above starting methods in terms of performance and relative cost
- select a suitable starter to meet a given induction motor application

The assessment for Outcome 3 and the first six bullet points in Outcome 4 must be combined together to form one assessment paper. This single assessment paper must be taken at a single assessment event lasting one hour and fifteen minutes and must be carried out under supervised, controlled conditions. Assessment must 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 should be permitted to use scientific calculators during the assessment.

The assessment for bullet point 7 in Outcome 4 must consist of an assignment in which a candidate is required to select a suitable starter for a three-phase induction motor and justifies its selection. Candidate evidence should be presented in the form of a short report. Candidates should prepare the reports in their own time.

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

Assessment guidelines

The assessment paper should be composed of an appropriate balance of short answer, restricted response and structured questions. Candidates may use diagrams to assist their explanations.

With regard to the assessment of bullet point 7 centres may make the selection open ended or give candidates a choice of, say, four starters from which they select the most appropriate one for the given induction motor application. Centres may choose to allow candidates to confirm their starter selection by testing it out in practice. Assignment reports should normally be between 250 — 350 words in length plus diagrams and technical information. Centres may wish to provide candidates with a format for their reports or leave it to the candidates to develop their own reports.

Administrative Information

Unit code: DV9M 34

Unit title: Electrical Motors and Motor Starting

Superclass category: XJ

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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: Electrical Motors and Motor Starting

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, understanding and skills in the following areas:

1 The construction, principles of operation and characteristics of a Universal Motor.
2 The construction, principles of operation and characteristics of Single Phase Induction Motors.
3 The construction, principle of operation and performance characteristics of Three Phase Induction Motors.
4 Three-Phase Induction Motor Starting Methods (including the selection of a starter for a given application).

This Unit has been developed to provide Advanced Certificate in Electrical Engineering/HNC Engineering Practice candidates with a sound knowledge and understanding of the construction, operation and performance characteristics of universal, single-phase and three-phase induction motors and common methods of starting used with three-phase induction motors. The Electrical Motors and Motor Starting Unit is a 1credit unit at SCQF Level 7 (8 SCQF credit points at SCQF Level 7). It is included within the core section of the Advanced Certificate in Electrical Engineering framework. The Unit can also be offered on a free standing basis.

In designing this Unit, the Unit 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.

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 (8 Hours) **Explain the construction, principles of operation and characteristics of a Universal Motor.**

- Review of the constructional features and operation of dc motors
- Series, shunt and compound winding configurations
- Performance characteristics of principal dc motor types
- Principle of operation of universal motor (dc series motor supplied from ac supply)
- Performance characteristics of universal motor
- Typical applications
- Maintenance requirements of universal motor

Higher National Unit specification: support notes (cont)

Unit title: Electrical Motors and Motor Starting

Outcome 2 (8½ Hours) **Explain the construction, principles of operation and characteristics of Single Phase Induction Motors.**

- Explanation with diagrams of the creation of a rotating magnetic field from a single phase supply
- Main constructional features and principle of operation of main types of single phase motors (split phase, capacitor start, capacitor start — capacitor run, shaded pole)
- Torque speed characteristics of motor types
- Typical applications of main motor types
- Maintenance requirements of principal motor types

Assessment – 1hour and 15minutes

Outcome 3 (9 Hours) **Explain the construction, principle of operation and performance characteristics of Three Phase Induction Motors.**

- Identify the main constructional features of three-phase induction motors
- Explain the principle of operation of a three-phase induction motor
- Explain the terms synchronous speed and slip and perform calculations involving these two quantities
- Explain, with the aid of torque — slip curves, the performance characteristics of a three-phase induction motor subject to different types of loads
- Explain two applications of three-phase induction motors
- Explain maintenance requirements of squirrel cage and wound rotor induction motors

Outcome 4 (12-hours) **Explain and select Three-Phase Induction Motor Starting Methods**

- Discussion of normal and adverse starting conditions (eg high inertia loads, high starting currents, potential serious volt-drops)
- Duty cycle
- Description, principle of operation, circuit and wiring diagrams for the following starting methods: Direct-on-Line, Star-Delta, Auto-Transformer and Rotor Resistance (wound rotor motors only)
- Brief discussion of starting problems (eg motor taking too long to reach full speed, motor not reaching full speed, cogging)
- Practical issues relating to starting (eg six stator winding ends required in the case of Star-Delta Starting)
- Principles of soft-starting and typical soft-starting arrangements
- Comparison of starting methods in terms of overall performance and relative cost
- Selection of starter for given induction motor application

Assessment — 1 hour and fifteen minutes (last bullet excluded)

Higher National Unit specification: support notes (cont)

Unit title: Electrical Motors and Motor Starting

Guidance on the delivery and assessment of this Unit

This Unit has been designed to incorporate sufficient time to allow lecturers to teach all of the electrical motor content contained in the Unit. There is also sufficient time for candidates to practice what they have learnt through appropriate formative assessment exercises and practical laboratory work. In regard to practical work, it is strongly recommended that candidates are allowed to study disassembled motors so that they can examine the various component parts of different motors. Good charts and other visual aids showing the disassembled parts of motors will also assist candidates to learn. Visual inspection of different types of three-phase induction motor starting systems will also aid learning. Centres are strongly recommended to allow candidates to perform a range of practical test on motors to determine essential performance characteristics. This will help candidates to relate theory to practice.

Information on Evidence requirements and Assessment guidelines is given after Outcomes 2 and 4 in the Higher National Unit specification: statement of standards section. The first assessment paper should take place after Outcomes 1 and 2 have been completed and the second assessment paper after Outcomes 3 and 4 are completed. The assignment on selecting a starter for a three phase induction motor should take place towards the end of the Unit.

Opportunities for developing Core Skills

During the delivery of the Unit candidates should be exposed to graphical information in various forms (eg phasor representations, torque — speed characteristics). Such exposure should help to strengthen their Using Graphical Information core skill. Lecturers should use their teaching and formative assessment to encourage candidates to think clearly about how the different types of motors and starters work and where they can be applied. This approach should help to develop candidates Critical Thinking skills. The motor starter selection assignment should also provide scope for developing Critical Thinking skills. Preparing the report on starter selection should help to develop candidates Written Communication Skills.

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line 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 the two assessment papers, whether done at a single or multiple events, were conducted under controlled, supervised conditions.

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

Higher National Unit specification: support notes (cont)

Unit title: Electrical Motors and Motor Starting

Candidates with disabilities and/or additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative Outcomes for Units. For information on these, please refer to the SQA document *Guidance on Alternative Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs,* which is available on SQA's website: **www.sqa.org.uk**.

General information for candidates

Unit title: Electrical Motors and Motor Starting

Universal and single-phase induction motors are used widely in both domestic and light industrial applications. The three-phase induction motor is the most widely used motor in industry principally because it is cheap, robust and has minimal maintenance requirements. It is very important that you understand the construction, operation and main performance characteristics of these types of motors as you may take on responsibility for installing and maintaining them.

The centre where you study this Unit will probably provide you with opportunities to study the component parts of the different motors closely using disassembled motors, charts and other visual aids. You will also probably perform various tests on motors to determine their key performance parameters and characteristics.

Assessment for this Unit will comprise of two, one hour and fifteen minutes assessment papers conducted under controlled, supervised conditions. You will sit the first test after Outcomes 1 and 2 have been completed and the second test after Outcomes 3 and 4 have been completed. Both tests will be closed book so you will not be allowed to bring any notes, handouts or textbooks into the assessments. You will also be required to undertake an assignment in which you select a suitable starter for a given three phase induction motor application. You will be required to produce a short report justifying your selection.