Higher National Unit Specification

General information

Unit title: Operating Principles of an Electrolytic Hydrogen Facility (SCQF level 7)

Unit code: J64P 34

Superclass: YB

Publication date: March 2022

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

The purpose of this unit is to provide learners with knowledge and skills specific to the operation, maintenance and servicing of electrolytic hydrogen facilities and items of plant that are commonly found in such environments.

This unit has been developed as part of the PDA in Hydrogen: An Introduction for Technicians however it is also available as a freestanding unit.

Outcomes

On successful completion of the unit the learner will be able to:

1 Describe the electrical aspects and basic operation of 48 VDC* systems.
2 Understand low- and high-pressure electrolytic hydrogen systems.
3 Perform generic procedures applicable to the operation and maintenance of electrolysis plant and battery cell systems.
4 Perform generic procedures for monitoring a hydrogen facility.

* VDC: Voltage (Direct Current)

Credit points and level

1 Higher National Unit credit at SCQF level 7: (8 SCQF credit points at SCQF level 7)

Higher National Unit Specification: General information (cont)

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Recommended entry to the unit

Access to this unit is at the discretion of the centre. However, it is recommended that learners have completed the unit J5SJ 33 *Safe Hydrogen Gas Handling* before commencing this unit.

It would also be advantageous for learners to have completed, or be studying towards, qualifications that develop core engineering design and analysis skills. These could include, but are not limited to, NC or HNC qualifications in: Electrical Engineering, Mechanical Engineering, Engineering Systems, Manufacturing Engineering or Measurement and Control Engineering.

Additionally, learners will benefit from having attained Higher level education in STEM subjects such as Maths and Science or SVQ in engineering disciplines such as Mechanical, Manufacturing or Electrical Engineering.

Learners with suitable relevant industrial experience or qualifications may also be considered, in particular those working in the renewable energy sector.

Higher National Unit Specification: General information (cont)

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Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the support notes for this unit specification.

There is no automatic certification of Core Skills or Core Skill components in this unit.

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.

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**.

Higher National Unit Specification: Statement of standards

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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.

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. Learners 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

Describe the electrical aspects and basic operation of 48 VDC systems.

Knowledge and/or skills

- DC electrical terminology — voltage, current, power, and resistance.
- The basic operation of electrical power cells.
- Electrical distribution in DC system.
- Basic electrical calculations — Voltage transformation, voltage drop and Ohm's law.

Outcome 2

Understand low- and high-pressure electrolytic hydrogen systems.

Knowledge and/or skills

- The properties of hydrogen derived from thermodynamics, including energy transformations.
- The energy required to pressurise hydrogen gas.
- The characteristics of basic low- and high-pressure hydrogen systems.
- Basic fluid dynamics applied to the flow of hydrogen gas.

Outcome 3

Perform generic procedures applicable to the operation and maintenance of electrolysis plant and battery cell systems.

Knowledge and/or skills

- Switching between the operating modes of the plant.
- Physical procedures (understanding the correct torque for joints, installing pipework, electrical wiring testing).
- Maintenance procedures (leak testing and checking procedures, maintenance of test rigs, installing and replacing monitoring devices and regulators, calibration procedures).

Outcome 4

Perform generic procedures for monitoring a hydrogen facility.

Knowledge and/or skills

- Data logging, fault-finding and diagnostics.
- Basic calculations to establish the performance and efficiency of an operational system.
- Verify operational safety.

Evidence requirements for this unit

Outcome 1

Learners will need to provide written and/or oral recorded evidence to demonstrate their knowledge and/or skills by showing the following:

(a) The learner will understand the phenomena governing the behaviour of an electrical system, eg: charge, voltage, current, power, and resistance.
(b) The learner will understand the common modes of construction of various electrical power cell designs and their basic operation. In particular, the learner will understand the operation of a power cell when being charged or discharged and the essential equipment used with each mode of operation.
(c) The learner will understand the basic principles of operation of an electrical distribution system, particular to a low voltage DC system, including the connection and disconnection of loads, basic principles of fault detection and management, switching procedures, earth switching and isolation switching.
(d) The learner will understand the fundamental electrical system calculations that are useful to inform a competent operator of electrical plant. Calculations may include voltage drop cable calculations, voltage transformations, and the calculation of the State of Charge (SOC) of a battery cell system.

The assessment of Outcomes 1 and 2 should be combined. Learners are required to provide written and/or oral recorded evidence, generated under open-book, supervised, timed conditions.

Higher National Unit Specification: Statement of standards (cont)

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Outcome 2

Learners will need to provide written and/or oral recorded evidence to demonstrate their knowledge and/or skills by showing the following:

(a) The learner will understand the basic properties of hydrogen as derived from thermodynamics by treating hydrogen as an ideal gas at low pressure. The energy consumption and cost of electrolysis should be understood, along with the derivation of the higher and lower heating values.
(b) The learner will understand different ways hydrogen is pressurised and how much energy is required (and the impact this has on the effectiveness of hydrogen as an energy carrier). Learners will understand that the gas deviates from the ideal gas relations at high pressure.
(c) The learner will understand the common operation and general maintenance requirements of electrolytic hydrogen systems, recognising that any specific item of plant will have particular maintenance requirements.
(d) The learner will gain a basic understanding of the principles of flow applied to hydrogen in pipes.

The assessment of Outcomes 1 and 2 should be combined. Learners are required to provide written and/or oral recorded evidence, generated under open-book, supervised, timed conditions.

Outcome 3

Learners will need to provide product evidence to demonstrate their knowledge and/or skills by showing the following:

(a) The learner understands the key current industrial documentation and roles that inform the actions of employees working in any specific hydrogen facility, e.g. plant specific safety cases documentation, normal operating procedures, and emergency operating procedures. The learner gains practical experience in the procedures currently employed within the hydrogen industry to ensure safe operation of electrolysis plant and fuel cell systems. In particular, the learner shall be able to switch between operating modes.
(b) The learner will be able to assemble a section of pipework, ensuring the correct fittings are used to connect into the existing system, and check the assembly for leaks. The learner will be able to make 48 VDC electrical connections securely and safely.
(c) The learner will be able to demonstrate the use of gas leak detection equipment and adopt maintenance practices appropriate to test rigs. The learner is able to install and replace regulators and sensors and apply calibration procedures.

Evidence for the knowledge and/or skills in this outcome will be generated under open-book, unseen conditions.

Higher National Unit Specification: Statement of standards (cont)

Unit title: Operating Principles of an Electrolytic Hydrogen Facility (SCQF level 7)

Outcome 4

Learners will need to provide product evidence to demonstrate their knowledge and/or skills by showing the following:

(a) The learner will gain practical experience of the procedures and equipment used to find and diagnose the source of faults in electrolysis plant and fuel cell systems. The learner will learn the recommended procedures to follow on initial fault detection, fault diagnosis, repair, and returning the plant to service.
(b) The learner will gain practical experience in taking live measurements from an operational hydrogen facility (including the use of data loggers to capture historic data) and uses these measurements to evaluate the system's operational status. The learner understands how to make an accurate estimation of system component losses and determines the overall system performance of a hydrogen facility by aggregating all losses.
(c) The learner is able to check and verify the safety of the system.

Evidence for the knowledge and/or skills in this outcome will be generated under open-book, unseen conditions.

Higher National Unit Support Notes

Unit title: Operating Principles of an Electrolytic Hydrogen Facility (SCQF level 7)

Unit support notes are offered as guidance and 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 developed to provide learners with the necessary knowledge and skills appropriate to working in the hydrogen gas industry. It is designed to instil in learners both the necessary knowledge and practical experience required of a competent technician-level hydrogen plant operator.

- In Outcome 1, learners are introduced to the fundamental knowledge and principles of operation of a 48 VDC electrical power system including: power cells and electrical distribution. Having knowledge of this equipment, its operation and maintenance requirements is essential in the electrolytic hydrogen gas industry where these systems are employed. Having a strong grasp of such systems will provide learners with a generalised skillset and knowledge base to support a future career in the hydrogen industry.
- In Outcome 2, learners are introduced to the fundamental knowledge and principles of operation of low and high-pressure systems. Similar to Outcome 1, these systems are commonly employed in the hydrogen industry and, as such, having knowledge of this equipment, its operation and maintenance requirements provides learners with a generalised skillset and knowledge base to support employment in a hydrogen facility and a future career in the hydrogen industry.
- In Outcome 3, learners are provided with practical experience of correct procedures for the operation and maintenance of electrolysis plant and fuel cell systems to ensure that they have the skills necessary to work with these specific items of plant found in hydrogen facilities. Learners will learn generalised industry procedures, the application of which are intended to enable correct operation of plant whilst always maintaining a working environment that is safe for both the learner and their fellow employees. Skills are further embedded by exposing learners to the practical physical activities of operating these items of plant, to familiarise the learner with actual equipment that they may come across in the hydrogen industry.
- In Outcome 4, learners are provided with practical experience of how to take live measurements to determine the operating condition of a hydrogen facility. Understanding what data is required, how to capture data, and how to use this data to determine the performance of various items of plant and the facility as a whole, is an essential skillset for a hydrogen facility operator. In addition, understanding the nature of how physical plant operates provides the learner with a depth of industry specific knowledge that will benefit them as they continue to develop their career in the hydrogen industry.

Higher National Unit Support Notes (cont)

Unit title: Operating Principles of an Electrolytic Hydrogen Facility (SCQF level 7)

Guidance on approaches to delivery of this unit

It is anticipated that a sequential approach to delivery should be taken, where learners gain fundamental knowledge by studying and completing Outcomes 1 and 2, before moving onto learning the practical skills contained in Outcomes 3 and 4.

Outcomes 1 and 2 shall principally be delivered in a classroom or virtual learning environment. Outcomes 3 and 4 shall be delivered either in an industrial setting (with operating and maintenance procedures being demonstrated on real electrolytic hydrogen plant) or in a simulated environment created in an academic institution laboratory. Note that it is expected that the simulated environment offers access to some industrial equipment, eg, power cells, pressure regulators, etc, such that learners are exposed to training in the necessary the practical skills.

- Practical skills can be learned in an isolated or part-system.
- Safe-gas systems could be used for demonstration purposes.
- The learner should have electrolysis plant and fuel cell apparatus available to them either in an industrial environment or in a video or in a sequence of still images.
- The learner should have appropriate testing equipment and tools available to them either in an industrial environment or in a video or in a sequence of still images.
- The learner should have hydrogen facility plant available to them on which to demonstrate the procedure for taking measurements. This may be achieved in an industrial environment or in a video or in a sequence of still images.
- The learner should be guided through appropriate procedures by a suitably qualified and experienced person.
- The learner should have appropriate measurement equipment and data logging equipment available to them either in an industrial environment or in a video or in a sequence of still images.

The information pertaining to each outcome could be delivered through a mix of knowledge delivery and video clips and is suitable for remote delivery.

The exact distribution of time between outcomes is at the discretion of the centre, however, the expected time requirements for each outcome, including the assessment of Outcomes 1 and 2, are as follows:

- Outcome 1 — 8 hours.
- Outcome 2 — 12 hours.
- Outcome 3 — 13 hours.
- Outcome 4 — 7 hours.

Higher National Unit Support Notes (cont)

Unit title: Operating Principles of an Electrolytic Hydrogen Facility (SCQF level 7)

Guidance on approaches to assessment of this unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

- Outcomes 1 and 2 could be assessed through one extended (multi-part) examination. The exam could include calculation exercises, short response form questions and multiple-choice form questions. Learners shall be expected to complete the exercise in an open-book examination environment under supervised conditions. The duration of this exercise should not exceed two hours.
- Outcome 3 involves practical exercises and could be assessed by the use of observation checklists and the submission of a short report outlining the correct operating and maintenance procedures that the learner has practiced in reference to electrolysis plant and fuel cell systems. The report shall be assessed by a suitably qualified and experienced person (either in industry or academia), who shall determine whether the learner has demonstrated in their report that they have an adequate understanding of the correct procedures. It should be noted that this evidence will demonstrate practical experience specific to the equipment available to the assessment centre though additional training will be required for specific items of equipment that learners encounter in their future career.
- Outcome 4 involves practical exercises and could be assessed by the use of observation checklists and the submission of a short report outlining the service and maintenance procedures that the learner has practiced in reference to a hydrogen facility, including the practice of taking measurements and how data can be used to approximate the operating condition of the facility. The report shall be assessed by a suitably qualified and experienced person (either in industry or academia), who shall determine whether the learner has demonstrated in their report that they have an adequate understanding of the correct procedures. It should be noted that this evidence will demonstrate practical experience specific to the equipment available to the assessment centre though additional training will be required for specific items of equipment that learners encounter in their future career.

Opportunities for 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 social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the evidence requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Higher National Unit Support Notes (cont)

Unit title: Operating Principles of an Electrolytic Hydrogen Facility (SCQF level 7)

Opportunities for developing Core and other essential skills

There are opportunities to develop the following Core Skills in this unit.

Communication, at SCQF level 6, can be developed in learners across all outcomes of this unit. In Outcomes 1 and 2, learners will be exposed to written learning materials and will be expected to discern relevant information. Learners will have the opportunity to discuss materials with fellow colleagues and present their learnings in a clear and concise manner. Oral communication skills will be developed principally in Outcomes 3 and 4, in which learners are exposed to practical skills in an industrial (or emulated) environment. Learners will be expected to learn by verbal instruction (supported by a demonstration where appropriate) and will have the opportunity to interact with instructors and fellow learners by questioning instructions or sharing understandings.

Numeracy component *Using Number*, at SCQF level 6, can be developed by learners carrying out the calculations associated with DC electrical systems in Outcome 1, fluid dynamics in Outcome 2 and facility performance in Outcome 4.

Information and Communication Technology component *Accessing Information*, at SCQF level 6, can be developed by learners using the internet to access resources.

Problem Solving components *Critical Thinking* and *Reviewing and Evaluating*, at SCQF level 6, across all outcomes of this unit. In Outcomes 1 and 2, learners will be exposed to mathematical problems associated with DC electrical system calculations and fluid dynamics calculations. In Outcome 4 learners will have the opportunity to learn how to take measurements of an operational hydrogen facility and how to use measured data to estimate losses and calculate the performance of the facility.

Working with Others, at SCQF level 6, can be developed by using group work within the classroom, industrial and laboratory settings, which allows learners to share experiences with their fellow learners. Groups will be encouraged to collaborate to get the most out of their learning experience and to bring forth best practices and understandings to the benefit of all.

This is a rapidly developing sector with significant employment opportunities foreseen, including the transition of workers from the Oil and Gas sector to hydrogen production facilities.

The unit can provide strong underpinning skills for units such as Design Principles of a Hydrogen System.

History of changes to unit

Version	Description of change	Date

General information for learners

Unit title: Operating Principles of an Electrolytic Hydrogen Facility (SCQF level 7)

This section will help you decide whether this is the unit for you by explaining what the unit is about, what you should know or be able to do before you start, what you will need to do during the unit and opportunities for further learning and employment.

Following detailed analysis of current and anticipated hydrogen activity in Scotland and Europe, it was concluded that there is reasonable expectation of hydrogen technologies making a significant contribution to the Scottish economy over the next 10 years and beyond.

In order to develop the skills required to meet the skill gap in the hydrogen sector, this unit will educate learners in the operation and maintenance of several key technologies employed in a hydrogen facility.

The aim of this unit is to provide you with fundamental knowledge and skills appropriate to working in the hydrogen gas industry. In addition, in completing this unit you will have the opportunity to develop Core Skills and components of core skills at SCQF level 6.

This unit has been developed as part of the PDA in Hydrogen: An Introduction for Technicians, however, is also available as a freestanding unit. The PDA in Hydrogen: An Introduction for Technicians is a three-unit course that offers an industry and SQA recognised certification demonstrating technician-level training in hydrogen technologies and provides learners with the opportunity to develop current and future skills to meet the needs of industry. The other two units in the PDA are: *Safe Hydrogen Gas Handling* at SCQF level 6 and *Design Principles of a Hydrogen System* at SCQF level 8.

- In Outcome 1, you are introduced to the fundamental knowledge and principles of operation of a 48 VDC electrical power system including: power cells and electrical distribution. Having knowledge of this equipment, its operation and maintenance requirements is essential in the hydrogen gas industry where these systems are commonly employed. Having a strong grasp of such systems will provide you with a generalised skillset and knowledge base to support a future career in the hydrogen industry.
- In Outcome 2, you are introduced to the fundamental knowledge and principles of operation of low and high-pressure systems. Similar to Outcome 1, these systems are commonly employed in the hydrogen industry and, as such, having knowledge of this equipment, its operation and maintenance requirements provide you with a generalised skillset and knowledge base to support employment in a hydrogen facility and a future career in the hydrogen industry.
- In Outcome 3, you are provided with practical experience of correct procedures for the operation and maintenance of electrolysis plant and fuel cell systems to ensure that they have the skills necessary to work with these specific items of plant found in hydrogen facilities. You will learn generalised industry procedures, the application of which are intended to enable correct operation of plant whilst always maintaining a working environment that is safe for both the learner and their fellow employees. Skills are further embedded by exposing you to the practical physical activities of operating these items of plant, to familiarise you to actual equipment that they may come across in the hydrogen industry.

General information for learners (cont)

Unit title: Operating Principles of an Electrolytic Hydrogen Facility (SCQF level 7)

- In Outcome 4, you are provided with the practical experience of how to take live measurements to determine the operating condition of a hydrogen plant facility. Understanding what data is required, how to capture data, and how to use this data to determine the performance of various items of plant and the facility as a whole, is an essential skillset for a hydrogen facility operator. In addition, understanding the nature of how physical plant operates provides you with a depth of industry specific knowledge that will benefit them as they continue to develop their career in the hydrogen industry.

On successful completion of the unit you, will be able to:

1 Describe the electrical aspects and basic operation of 48 VDC systems.
2 Understand low- and high-pressure electrolytic hydrogen systems.
3 Perform generic procedures applicable to the operation and maintenance of electrolysis plant and battery cell systems.
4 Perform generic procedures for monitoring a hydrogen facility.

Outcomes 1 and 2 of this unit will be assessed by written and/or recorded oral evidence in a supervised, open-book and timed assessment environment. For Outcomes 3 and 4, you will provide product evidence generated under open-book, unseen conditions.