Higher National Unit specification

General information

Unit title: Process Water and Steam Services (SCQF level 7)

Unit code: HE3H 34

Superclass: YC

Publication date: June 2016

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to enable learners to understand key aspects of the provision and use of water and steam services in the oil refining and chemicals manufacturing industries. This Unit is suitable for learners studying at HNC level, and will provide the necessary underpinning knowledge and skills to enable progression to further study of chemical engineering or to seek employment in the oil refining and chemicals processing industries.

Outcomes

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

1 Explain the principal methods of steam production used in the oil refining and chemicals manufacturing industries.
2 Explain the principal methods of water treatment used in the oil refining and chemicals manufacturing industries.
3 Perform practical experiments related to using energy balances to estimate the efficiency of steam utilisation and water cooling processes.

Credit points and level

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

Recommended entry to the Unit

Entry is at the discretion of the centre, however it is recommended that learners should have completed the HN Unit *Chemical Engineering: Principles* (H97N 34) or equivalent, or have experience of Mathematics at SCQF level 6.

General information (cont)

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Core Skills

Achievement of this Unit gives automatic certification of the following Core Skills component:

Complete Core Skill None

Core Skill component Using Number at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

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

Explain the principal methods of steam production used in the oil refining and chemicals manufacturing industries.

Knowledge and/or Skills

- Fire-tube boilers
- Water-tube boilers
- Steam distribution equipment
- Heat exchange equipment for steam utilisation

Outcome 2

Explain the principal methods of water treatment used in the oil refining and chemicals manufacturing industries.

Knowledge and/or Skills

- Feed water conditioning for fire-tube boilers
- Feed water conditioning for water-tube boilers
- Treatment of cooling water
- Treatment of waste water

Outcome 3

Perform practical experiments related to using energy balances to estimate the efficiency of steam utilisation and water cooling processes.

Knowledge and/or Skills

- Energy balances experiments
- Working safely, within current health and safety regulations
- Consistent and accurate results
- Recording observations and results
- Evaluation skills
- Result analysis and conclusions

Higher National Unit specification: Statement of standards (cont)

Unit title: Process Water and Steam Services (SCQF level 7)

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1 and 2 should be assessed using a holistic open-book assessment under supervised conditions. The assessment will use a sampling approach to the Knowledge and/or Skills as detailed below. It is recommended that the assessment be completed within two hours.

Written and/or oral recorded evidence for Outcome 3 should be assessed by production of a full laboratory report, or by completion of an appropriate pro forma. An assessor's observation checklist could be used to record performance evidence of practical experiments.

Outcome 1

The assessment will sample three of the four Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- explain the design and method of operation of fire-tube boilers. The explanation must include one single pass and one multiple pass configuration and the operating characteristics including boiler water condition monitoring and blow-down procedures.
- explain the design and method of operation of water-tube boilers. The explanation must include combined heat and power installations and the operating characteristics including tube surface condition monitoring and blow-down procedures.
- explain the design and method of operation of equipment which contributes to the safe and effective distribution of steam. The explanation must include pressure reduction valves, pressure relief valves, steam traps and expansion loops as well as corrosion problems in condensate return lines and their solutions.
- explain the design and method of operation of heat exchange equipment for steam utilisation including shell and tube heat exchangers and plate heat exchangers.

Outcome 2

The assessment will sample three of the four Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- explain the design and method of operation of processes for the safe conditioning of feed water to fire-tube boilers. The explanation must include two processes from: scale formation by calcium and magnesium, ion-exchange water softening equipment and processes, chemical control of calcium and magnesium, oxygen corrosion, chemical removal of oxygen, alkaline passivation of steel, metering pumps for additive delivery, conductivity measurements, total dissolved solids and the blow-down cycle.
- explain the design and method of operation of processes for the safe conditioning of feed water to water-tube boilers. The explanation must include deaeration and demineralisation.
- explain the design and method of operation of cooling towers and cooling cycles.
- explain the design and method of operation of two processes for the treatment of waste water. The explanation must include two processes from removal of oils, flocculation and sedimentation and biological treatment methods. The explanation must also include indicators of water quality.

Outcome 3

Learners will perform a minimum of two practical experiments, the content of which will be related to Outcomes 1–2. A learner's response will be judged satisfactory where the evidence shows that the learner can achieve all of the following:

- follow instructions to perform experiments related to energy balances.
- work in a safe manner regarding current health and safety regulations.
- achieve consistent and accurate results.
- record experimental observations and results clearly and accurately.
- evaluate validity of results in terms of sources of and values of experimental errors.
- analyse results correctly and state valid conclusions.

Where calculations are performed, the learner must:

- apply appropriate formulae.
- apply the principles of the calculation.
- show all working through a calculation.
- provide reasonable answers to the questions asked. The answer should derive from the application of the formulae and correct application of the principles of the calculation.

An assessor observation checklist will be used to record the learner's performance of the practical work in line with given instructions and health and safety requirements.

Higher National Unit specification: Statement of standards (cont)

Unit title: Process Water and Steam Services (SCQF level 7)

Learners must report one of the two practical experiments by production of a full laboratory report. Learners may report the remaining practical experiment by production of a full laboratory report or by completion of an appropriate pro forma. Where a pro forma approach is deployed, the pro forma will not present information or assistance to the learners on how to correctly perform calculations, analyse experimental results or experimental errors. Learners will be expected to perform such activities independently on the basis of the experimental data.

Where a learner does not perform an assessed practical experiment to the required standard, they will be given the chance to either reattempt the same practical experiment, or to undertake different practical experiments of similar complexity. Where a laboratory report or pro forma does not meet the required standard, then the learner will be given a single opportunity to re-draft. If the required standard is still not attained, then an alternative practical experiment will be set.

Higher National Unit Support Notes

Unit title: Process Water and Steam Services (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 is intended as part of the framework for HNC Chemical Engineering and HNC/HND Chemical Process Technology but may be suitable for inclusion in other HN engineering awards. It is designed to provide learners with knowledge of the provision and use of water and steam services in the oil refining and chemicals manufacturing industries.

Outcome 1 — Explain the principal methods of steam production used in the oil refining and chemicals manufacturing industries

The principle methods of operation of fire-tube steam raising equipment (shell boilers):

- Historic origins of the fire-tube boiler
- Contemporary designs, including single pass and multiple pass configurations
- Operating characteristics of fire-tube boilers, including boiler water condition monitoring and blow-down procedures
- Pressure Vessel Regulations, insurance requirements and annual inspections
- Corrosion problems in fire-tube boilers and their solutions
- Scaling problems in fire-tube boilers and their solutions

The principle methods of operation of water-tube steam raising equipment:

- Historic origins of the water-tube boiler
- Contemporary designs, including combined heat and power installations
- Operating characteristics of water-tube boilers, including tube surface condition monitoring and blow-down procedures
- Corrosion problems in water-tube boilers and their solutions
- Scaling problems in water-tube boilers and their solutions

The principle methods of operation of equipment which contributes to the safe and effective distribution of steam:

- Pressure reduction valves, pressure relief valves, steam traps and expansion loops
- Corrosion problems in condensate return lines and their solutions

Higher National Unit Support Notes (cont)

Unit title: Process Water and Steam Services (SCQF level 7)

The principle methods of operation of heat exchange equipment for steam utilisation in oil refining and chemicals processing:

- Steam jackets, internal tube bundles, external reboilers
- Shell and tube heat exchangers, plate heat exchangers

Outcome 2 — Explain the principal methods of water treatment used in the oil refining and chemicals manufacturing industries

Feed water conditioning for fire-tube boilers:

- Scale formation by calcium and magnesium
- Ion-exchange water softening equipment and processes
- Chemical control of calcium and magnesium
- Oxygen corrosion
- Chemical removal of oxygen
- Alkaline passivation of steel
- Metering pumps for additive delivery
- Conductivity measurements and Total Dissolved Solids
- The blow-down cycle

Feed water conditioning for water-tube boilers:

- Deaeration equipment and processes
- Demineralisation equipment and processes

Cooling water recycling:

- Open and closed cooling cycles
- Natural draught cooling towers
- Forced draught cooling towers
- Induced draught cooling towers
- Total Dissolved Solids control in open systems
- Microbiological control, particularly legionella

Waste water treatment:

- Removal of oils
- Flocculation and sedimentation
- Biological treatment methods
- Indicators of water quality

Higher National Unit Support Notes (cont)

Unit title: Process Water and Steam Services (SCQF level 7)

Outcome 3 — Perform practical experiments related to using energy balances to estimate the efficiency of steam utilisation and water cooling processes

Guidance on suitable practical experiments for assessment purposes is given elsewhere in this document. However, it is envisaged that learners will also participate in a range of other practical experiments which will both develop their laboratory skills and support the theory covered in Outcomes 1 and 2.

In carrying out such activities, learners should follow good laboratory practice and carry out or be familiar with the risk and Control of Substances Hazardous to Health (COSHH) assessments on all procedures undertaken. Opportunities should be taken to develop awareness of the sources of experimental error and of the accuracy of measurements, with quantification of errors where possible.

Guidance on approaches to delivery of this Unit

If this Unit is delivered as part of a Group Award, it is recommended where possible that the Unit is delivered in the later part of the Group Award, in order that learners have some knowledge of fluid mechanics and heat transfer before starting the Unit.

It is envisaged that Outcome 1 is delivered prior to Outcome 2. Outcome 1 could commence with the design and method of operation of both fire-tube boilers and water-tube boilers. Delivery could then focus on the design and method of operation of heat exchange equipment for steam utilisation including shell and tube heat exchangers and plate heat exchangers. Finally, the design and method of operation of equipment contributing to the safe and effective distribution of steam could be covered, including reduction valves, pressure relief valves, steam traps and expansion loops as well as corrosion problems in condensate return lines and their solutions.

Outcome 2 could commence with the design and method of operation of processes for the safe conditioning of feed water to fire-tube boilers. This should include an explanation of scale formation by calcium and magnesium, ion-exchange water softening equipment and processes, chemical control of calcium and magnesium, oxygen corrosion, chemical removal of oxygen, alkaline passivation of steel, metering pumps for additive delivery, conductivity measurements and total dissolved solids and the blow-down cycle. The design and method of operation of processes for the safe conditioning of feed water to water-tube boilers could then be covered, explaining deaeration and demineralisation. Delivery could then focus on the design and method of operation of cooling towers and cooling cycles. Finally, the design and method of operation of two processes for the treatment of waste water could be covered. This should include an explanation of removal of oils, flocculation and sedimentation and biological treatment methods as well as indicators of water quality.

It is envisaged that Outcome 3 is carried out after Outcome 1 is completed. Practical work for the experiment covered by a full laboratory report could include investigating rates of heat transfer using water and steam in a plate heat exchanger or rates of heat transfer using water and steam in a shell and tube heat exchanger. The practical work for the pro forma could include investigating Fulton boiler start up and shutdown procedure and feed water analysis.

Higher National Unit Support Notes (cont)

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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.

Outcomes 1 and 2 could be assessed by a single holistic open-book assessment with an appropriate cut-off score that covers the sampling requirements as detailed in the Evidence Requirements. Assessment should be carried out in supervised conditions. It is recommended that the assessment be completed within 2 hours. A suitable format could be six questions covering both Outcomes. The questions could require descriptions and explanations of representative steam raising equipment and methods of operation followed by descriptions and explanations of appropriate water treatment procedures.

Where evidence of Outcome 1 and Outcome 2 is assessed by sampling, the whole of the content listed in the Knowledge and/or Skills 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. Any items not sampled in the first assessment, must be included in the alternative (re-sit) assessment.

Outcome 1 and 2 are designed to assess understanding rather than recall. Therefore any assessment should reflect this, for example through learners having access to their own material, and any questions set should elicit an understanding of the material and the learner's problem solving ability.

In Outcome 3 learners are required to undertake two assessed practical experiments, the content of which will be related to Outcomes 1−2. Examples of suitable experiments are given below. However, this list is not prescriptive, and other practical experiments of similar complexity may be used by the centre.

Suitable practical experiments related to Outcome 1 and Outcome 2 are:

- investigating Fulton Boiler Start up and Shutdown Procedure and Feed Water Analysis.
- investigating Rates of Heat Transfer using Water and Steam in a Plate Heat Exchanger.
- investigating Rates of Heat Transfer using Water and Steam in a Shell and Tube Heat Exchanger.

The Evidence Requirements for Outcome 3 state that learners 'must provide a satisfactory response' which includes reasonable answers derived 'from the application of the formula and correct application of the principles of the calculation'. This allows for acknowledgement of the correct working and application of formulae, even where learners' final answer may be inaccurate. The statement allows for the eventuality where a single error at one stage in an extended calculation sequence has a cumulative effect on the final answer, even though working/formulae are otherwise correctly applied. Acknowledgement of the correct working should be given in such cases.

Assessed practical experiments will usually be performed individually. However, there may be some experiments that are suitable to be undertaken in pairs or small groups, if this is the case then the assessor should ensure that all participants are actively involved and are able to adequately demonstrate the required skills.

Higher National Unit Support Notes (cont)

Unit title: Process Water and Steam Services (SCQF level 7)

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.

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**.

Opportunities for developing Core and other essential skills

This Unit has the *Using Number* component of *Numeracy* embedded in it. This means that when learners achieve the Unit, their Core Skills profile will also be updated to show they have achieved *Using Number* at SCQF level 6.

The delivery and assessment of this Unit will also provide learners with the opportunity to develop the Core Skills of *Problem Solving* at SCQF level 6 and *Working with Others* at SCQF level 5.

***Problem Solving* — Critical Thinking at SCQF level 6**

Learners will be required to interpret and work through problems in assessments and during the laboratory aspect of this Unit.

***Working with Others* — Working Co-operatively with Others at SCQF level 5**

Learners will be required to work in partnership during the laboratory component of this Unit.

History of changes to Unit

Version	Description of change	Date

General information for learners

Unit title: Process Water and Steam Services (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.

This is a 1 credit Unit at SCQF level 7, which you are likely to be studying as part of the first year of a HNC/HND engineering or science programme. The Unit is designed to provide you with an overview of water and steam services in the oil refining and chemicals processing industries.

Entry is at the discretion of the centre, however it is recommended that learners should have completed the HN Unit *Chemical Engineering: Principles* (H97N 34) or equivalent, or have experience of Mathematics at SCQF level 6.

On completion of the Unit you should be able to:

1 Explain the principal methods of steam production used in the oil refining and chemicals manufacturing industries.
2 Explain the principal methods of water treatment used in the oil refining and chemicals manufacturing industries.
3 Perform practical experiments related to using energy balances to estimate the efficiency of steam utilisation and water cooling processes.

Assessment

For Outcomes 1 and 2, assessment will be conducted under open-book, supervised conditions.

Outcome 3 will be assessed after you have learned the necessary practical skills, and will take the form of two practical experiments. You will report the results from one procedure in a full laboratory report, and the other by a laboratory report or a pro forma.

Core Skills

This Unit has the Core Skill component of Using Number at SCQF level 6 embedded in it. You will also have opportunities to develop the Core Skills of *Problem Solving* at SCQF level 6, and *Working with Others* at SCQF level 5.