Higher National Unit specification

General information

Unit title: Process Safety Engineering (SCQF level 7)

Unit code: HE3F 34

Superclass: XA

Publication date: June 2016

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to enable learners to understand key aspects of safety engineering in the oil refining and chemicals processing 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 chemical, oil and allied industries.

Outcomes

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

1 Explain the management of fire and explosion hazards.
2 Explain the management of occupational and environmental hazards when handling harmful materials.
3 Explain the methods and techniques used in Quantitative Risk Assessment.
4 Analyse a hazardous incident.

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 prior knowledge of Health and Safety at SCQF level 6 or equivalent.

Higher National Unit specification: General information (cont)

Unit title: Process Safety Engineering (SCQF level 7)

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

Unit title: Process Safety Engineering (SCQF level 7)

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 management of fire and explosion hazards.

Knowledge and/or Skills

- Flammable and explosive materials
- Hazardous zones
- Safety equipment
- Sources of static electrical discharge
- Pressure vessels and their regulation

Outcome 2

Explain the management of occupational and environmental hazards when handling harmful materials.

Knowledge and/or Skills

- Classifications of harmful materials
- Methods of monitoring occupational exposure
- Maintenance of safe standards
- Methods of monitoring environmental exposure
- Methods of reporting
- Regulatory control of substances hazardous to health

Outcome 3

Explain the methods and techniques used in Quantitative Risk Assessment.

Knowledge and/or Skills

- Levels of risk
- Manual and automated activities
- The estimation of probability in random processes
- The estimation of failure rates in complex assemblies

Higher National Unit specification: Statement of standards (cont)

Unit title: Process Safety Engineering (SCQF level 7)

Outcome 4

Analyse a hazardous incident.

Knowledge and/or Skills

- Analysis
- Models
- Causes
- Prevention
- Improvements
- Recommendations

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1 and 2 could be assessed using a holistic closed-book assessment under supervised conditions. Outcomes may also be assessed individually. The assessment will use a sampling approach to the Knowledge and/or Skills as detailed below. It is recommended that the assessment — whether holistically or individually — be completed within 90 minutes. Learners can only have access to non-programmable calculators when sitting the assessment.

Written and/or oral recorded evidence for Outcome 3 should be assessed by a single closed-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 45 minutes. Learners can only have access to non-programmable calculators when sitting the assessment.

Written and/or oral recorded evidence for Outcome 4 should be assessed by production of a report carried out in open-book, unsupervised conditions.

Outcome 1

The assessment will sample three of the five 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 the learner can:

- classify gases, dusts, liquids and solid materials according to their fire and explosion hazards.
- explain the reasons behind the classification of gases, dusts, liquids and solid materials. The explanation must include two of the following five aspects: combustion reactions; vapour pressure; activation energy; ignition temperature; dust explosions.
- describe the classification of hazardous zones around flammable and explosive materials and the Approved Codes of Practice for safety equipment installations within zones.
- explain two sources of static electrical discharges and procedures or measures for their prevention.
- explain the management of fire and explosion hazards of pressure vessels. The explanation must include one of the following five aspects: the mechanical features of pressurised equipment; properties of materials and tensile stresses in curved walls; pressure relief valves; containment protection; the requirements of current legislation/ Approved Codes of Practice.

Outcome 2

The assessment will sample three of the five 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 the learner can:

- classify and explain the reasons behind the classification of toxic, irritant, corrosive and radioactive materials by chemical and physical type. The explanation must include three of the following nine aspects: acute toxicity; chronic toxicity; physical toxicity; cumulative poisons; carcinogens; heavy metals; aggressive particles; acidity and alkalinity; radioactive materials. One example of each classification must be included in the assessment.
- explain the methods of monitoring and reporting occupational exposure to harmful materials and the sources of reliable information on safe limits.
- explain methods used to maintain safe standards of occupational and environmental exposure. The explanation must include one of the following three aspects: maintenance or inspection programmes for equipment or instrumented safety systems; management programmes such as procedural controls; management programmes such as information and training.
- explain the methods of monitoring and reporting environmental exposure to harmful materials and the sources of reliable information on safe limits.
- explain the current legislative requirements for the control of substances hazardous to health (COSHH) and the implications for the management of hazardous materials. The explanation must include associated Approved Codes of Practice.

Higher National Unit specification: Statement of standards (cont)

Unit title: Process Safety Engineering (SCQF level 7)

Outcome 3

The assessment will sample two of the three 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 the learner can:

- explain methods for the quantification of risk in human activities and the observed levels of risk for a range of industrial and other activities. The explanation must include one of the following five aspects: Fatal Accident rate; Acceptable risk; ALARP; life cost estimates; cost-benefit analysis.
- apply basic probability theory for independent and simultaneous random events. The application must include one of the following three aspects: the calculation of Failure rates of mechanical and electrical equipment; demand rate; hazard rate.
- estimate the frequency of occurrence of hazardous conditions in a proposed manufacturing process. The estimation must include three of the following five aspects: Fault tree analysis; logical gates; probability of top event; duplication of safety equipment; the reduction of top event probability.

Where calculations are performed the learner must:

- apply appropriate formulae.
- apply the principles of the calculation.
- show workings 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.

Outcome 4

The assessment will cover all of the Knowledge and/or Skills items.

A learner's response will be judged satisfactory where the evidence shows that the learner can:

- systematically analyse a hazardous incident to identify the causes of the incident.
- recommend improvements or actions to prevent a recurrence of the incident.
- present the findings and recommendations.

The systematic analysis must use a case study approach or other acceptable model such as systems failure, fault tree analysis or cause and effect diagrams.

Findings and recommendations must be presented in a format that is in line with industry standards.

Higher National Unit Support Notes

Unit title: Process Safety Engineering (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/HND Chemical Process Technology and HNC Chemical Engineering but may be suitable for inclusion in other HN Engineering and Science awards. It is designed to enable learners to understand key aspects of safety engineering in the oil refining and chemicals processing industries.

Outcome 1 — Explain the management of fire and explosion hazards.

The classifications of flammable and explosive materials, the methods used to describe the level of hazard and the recommended procedures for safe operations:

- Combustion reactions and the fuel-air-ignition triangle
- Vapour pressure, explosive limit and flash point
- Gas grouping by activation energy and ignition temperature
- Dust explosions
- Storage of oils, volatile flammable liquids and LPGs

The classification of hazardous zones around flammable and explosive materials and the selection of equipment for use within them:

- Zones 0, 1 and 2 (BS 5345)
- Standard methods of explosion protection in electrical equipment
- Intrinsic safety

The common causes of static electrical discharges and methods for their prevention:

- Basic theory of static electrical charge accumulation and discharge
- Pumping of liquids into free space or insulated containers
- Electrical earthing of pipework and equipment

Pressure vessels and their associated safety equipment and the pressure vessel regulations:

- Mechanical features of pressurised equipment, properties of materials and tensile stresses in curved walls
- Pressure relief valves and containment protection
- Pressure Systems Safety Regulations and their Approved Codes of Practice (HSE) or equivalent regulations

Higher National Unit Support Notes (cont)

Unit title: Process Safety Engineering (SCQF level 7)

Outcome 2 — Explain the management of occupational and environmental hazards when handling harmful materials.

Classifications of toxic, irritant, corrosive and radioactive materials by chemical and physical types:

- Two examples of acute chemical toxicity such as chlorine, hydrogen sulphide, carbon monoxide, cyanides, biocides and any other relevant materials
- Two examples of chronic chemical toxicity such as cumulative poisons, carcinogens, heavy metals, arsenic, benzene and any other relevant materials
- Two examples of physical toxicity such as aggressive particles, asbestos and other mineral fibres
- Two examples of corrosive materials with reference to acids and alkalis and the pH scale
- Radioactive materials, levels of activity and safe limits of exposure

The methods of monitoring and reporting occupational exposure to harmful materials and the sources of reliable information on safe limits:

- LD50, WEL, TWA, STEL, LTEL and any other index of exposure
- Calculation of TWA from continuous records
- Reliable sources of MSDS information

The methods of monitoring and reporting environmental exposure to harmful materials and the sources of reliable information on safe limits:

- The carbon cycle and atmospheric warming
- CFC refrigerants and ozone depletion
- Cooling towers and legionellosis
- Reporting levels of contamination in atmospheric and aquatic samples
- SEPA and any other approved sources of environmental guidelines

The COSHH Regulations and any other relevant legislation:

- Control of Substances Hazardous to Health (COSHH) Regulations
- Approved Codes of Practice for substances of special interest

Higher National Unit Support Notes (cont)

Unit title: Process Safety Engineering (SCQF level 7)

Outcome 3 — Explain the methods and techniques used in Quantitative Risk Assessment.

Methods for the quantification of risk in general activities and the observed levels of risk associated with a variety of activities:

- The Fatal Accident Rate for a range of industrial and other activities
- Acceptable risk, the ALARP concept, 'as low as reasonably possible', life cost estimates and cost-benefit analysis

Basic probability theory for single random events and multiple simultaneous random events:

- Probability of random outcomes and random events
- Failure rates of mechanical and electrical equipment, demand rate, and hazard rate
- Combining probabilities of independent and simultaneous events

The estimation of the frequency of occurrence of hazardous conditions in a proposed manufacturing process:

- Fault tree analysis, logical gates, probability of top event
- Duplication of safety equipment and the reduction of top event probability

Outcome 4 — Analyse a hazardous incident

Preparation of a clear and concise report based on a historical hazardous incident within the oil extraction, oil refining or chemical processing, pharmaceutical or speciality chemical industries.

The historical hazardous incident should allow the learner to identify the causes of the incident and to recommend improvements or actions to prevent a recurrence of the incident. Learner's findings must be presented in a format that is in line with industry standards.

Examples of suitable historical hazardous incidents include:

- Deepwater Horizon/Gulf of Mexico Oil Spill 2010
- Buncefield Fire and Explosion 2005
- Texas City Oil Refinery Explosion 2005
- Piper Alpha Disaster 1988
- Bhopal Disaster 1984
- San Juanico Disaster 1984

Please note that this list is indicative only. Other historical hazardous incidents may be chosen by the learner or centre.

Higher National Unit Support Notes (cont)

Unit title: Process Safety Engineering (SCQF level 7)

During delivery of Outcome 4 learners should be supported when carrying out:

- On-line and/or off-line literature searching
- Authentication and referencing of source materials
- Identification of immediate and root causes
- Recommendations for the prevention of recurrence

Guidance on approaches to delivery of this Unit

Outcomes 1 and 2 can be delivered in any order, but it is envisaged that they are unlikely to be taught concurrently. It is envisaged that Outcome 3 will be taught on completion of Outcomes 1 and 2. Outcome 4 may be progressed concurrently with the other Outcomes in this Unit. Alternatively, it may be progressed on completion of any or all of the other Outcomes in this Unit.

It is envisaged that delivery of Outcome 1 could commence with combustion reactions and the fuel-air-ignition triangle. This could be followed by vapour pressure, explosive limits, activation energy, ignition temperature and flash point including the classification (including gas groups) and reasons behind the classification of gases, dusts, liquids and solids. Storage of oils, volatile flammable liquids and LPGs could be summarised. The classification of hazardous zones around flammable and explosive materials could follow on, with the Approved Codes of Practice for safety equipment installations in each zone. Basic theory of static electrical charge accumulation and discharge could then be taught, moving on to study of the sources of static electricity, with procedures and measures for their prevention such as electrical earthing of equipment, pipework and temporary containers, and elimination of pumping of liquids into free space. Pressure vessels and their regulation could then be covered. This would include the mechanical features of the pressurised equipment, properties of materials and tensile stresses in curved walls, pressure relief and containment protection and the requirements of the current legislation and Approved Codes of Practice.

It is envisaged that delivery of Outcome 2 could commence with study of occupational toxic, irritant, corrosive, radioactive hazard descriptions, including definitions for acute and chronic chemical hazards as well as physical toxicity. Within the study of acute chemical toxicity, at least two materials should be studied from chlorine, hydrogen sulphide, carbon monoxide, cyanides, biocides plus any other relevant materials. Within the study of chronic chemical toxicity, cumulative poisons should be studied with reference to arsenic or other heavy metals and carcinogens should be studied with reference to benzene or any other relevant materials. Physical toxicity could then be covered with reference to aggressive particles such as asbestos and other mineral fibres. The study of corrosive materials should include the hazards associated with acids and alkalis, and also the relevance of the pH scale. Examples of industrial corrosive acids and alkalis should be included during delivery. The study of radioactivity should include the levels of activity and safe limits of exposure. Industrial examples of likely sources of radioactive hazards should also be included. Methods of monitoring and reporting occupational exposure to harmful materials could commence with the study of LD50, WEL, TWA, LTEL and STEL and other index of exposure. This could be taught in conjunction with the COSHH Regulations (and other relevant regulations) and Approved Codes of Practice for substances of special interest. Methods of monitoring and reporting occupational exposure could also be covered at this point. As part of this study, learners should learn to perform simple calculations of TWA from continuous records.

Sources of reliable information on safe limits such as EH40 (HSE) and reliable sources of MSDS information should be identified. Methods of monitoring and reporting environmental exposure to harmful materials could commence with the study of the methods of monitoring and reporting environmental exposure, which could include study of the carbon cycle and atmospheric warming, CFC refrigerants and ozone layer depletion and environmental standards and reporting for atmospheric and aquatic samples. This could be followed by the hazards associated with cooling towers, the legionella bacterium and legionellosis. SEPA and approved sources of environmental guidelines could be referenced throughout this teaching.

It is envisaged that delivery of Outcome 3 could commence with the concept of fatal accident rates, followed by the concepts of acceptable risk, the ALARP concept, life cost estimates and cost-benefit analysis. This may be followed by the basic theory for single random and multiple simultaneous events. Delivery may continue with the probability of random outcomes based on everyday occurrences, which could then be applied to failure rates of mechanical and electrical equipment. Estimation of frequency of hazardous occurrences could be introduced at this point, with fault tree analysis, logical gates and probability of top event. This could then be followed by simultaneous failures of independent items and duplication of safety equipment, to reduce the probability of the top event.

Outcome 4 is intended to allow learners to analyse a historical hazardous incident. The hazardous incident will be chosen from the oil extraction, oil refining or chemical processing, pharmaceutical or speciality chemical industries. The choice of hazardous incident is at the discretion of the learner or centre, and suggested historical hazardous incidents are given elsewhere in this document. Delivery of Outcome 4 should allow learners to identify the causes of the historical hazardous incident and to recommend improvements or actions to prevent a recurrence of the incident. Work may be completed individually with partial supervision, or a specific manufacturing process may be studied in detail as a group exercise and reports prepared under supervised conditions, or any combination of these.

Independent study should be encouraged by the use of learner-centred learning material, although it is envisaged that learners will require a significant amount of planned instruction.

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 closed-book assessment with an appropriate cut-off score that covers the sampling requirements as detailed in the Evidence Requirements. Outcomes may also be assessed individually. Assessment should be carried out in supervised conditions. It is recommended that the assessment be completed within 90 minutes when both Outcomes are assessed together, or 45 minutes when assessed separately. Learners can only have access to non-programmable calculators when sitting the assessment. The assessment could be composed of an appropriate balance of short answer, restricted response and structured questions.

Higher National Unit Support Notes (cont)

Unit title: Process Safety Engineering (SCQF level 7)

Outcome 3 could be assessed by a single closed-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 45 minutes. Learners can only have access to non-programmable calculators when sitting the assessment.

For Outcome 3, the Evidence Requirements state that learners must 'provide reasonable answers' derived 'from the application of the formulae 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.

Where evidence of Outcomes 1–3 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 4 could be assessed though a case study approach. This could be in the form of a report analysing a hazardous incident. The report should be around 1,500 words or equivalent in length. The report should describe the incident in some detail, and explain the human, environmental and business consequences as applicable to that incident. The report should identify several immediate and root causes of the incident. The report should recommend improvements or actions to prevent a reoccurrence of a similar incident within the industry.

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.

Higher National Unit Support Notes (cont)

Unit title: Process Safety Engineering (SCQF level 7)

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

The delivery and assessment of this Unit will provide learners with the opportunity to develop the Core Skills of *Numeracy* at SCQF level 6 and *Problem Solving* at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skill components.

***Numeracy* — at SCQF level 6**

In Outcome 3 learners will be required to calculate risk probabilities, failure rates and other risk assessment calculations, as well as to use fault trees and logic gates.

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

In Outcome 4 learners will be required to analyse a hazardous situation.

History of changes to Unit

Version	Description of change	Date

General information for learners

Unit title: Process Safety Engineering (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 an HNC/HND engineering or science programme. The Unit is designed to provide you with an overview of hazard management in the oil-refining and chemicals industries, with special emphasis placed on the scientific and technical details on which best practice is based. The level of detail should be useful to you if you are employed or expecting employment in these industries at process operator or process technician level.

On completion of the Unit, you should be able to:

1 Explain the management of fire and explosion hazards.
2 Explain the management of occupational and environmental hazards when handling harmful materials.
3 Explain the methods and techniques used in Quantitative Risk Assessment.
4 Analyse a hazardous incident.

Assessment

For Outcomes 1 and 2, depending on which centre you attend, assessment may be conducted on an Outcome by Outcome basis or by one single assessment. Assessment will be conducted under closed-book, supervised conditions.

For Outcome 3, assessment will be conducted under closed-book, supervised conditions.

For Outcome 4 you will be assessed by the production of a report based on a real life historical incident. Assessment will be conducted under open-book, unsupervised conditions.

Core Skills

Although there is no automatic certification of Core Skills in the Unit, you will have opportunities to develop the Core Skills of *Numeracy* and *Problem Solving* at SCQF level 6.