Higher National Unit Specification

General information for centres

Unit title: Fermentation Engineering

Unit code: F3XA 34

Unit purpose: This Unit is designed to provide candidates with knowledge of fermentation engineering and its applications in beverage, chemicals and pharmaceuticals manufacturing.

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

1 Explain the operation of major types of bioreactor equipment.
2 Select equipment and procedures for fermentation processes.

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: Access to this Unit will be at the discretion of the centre, although mathematics at SCQF level 6 or equivalent, is recommended.

Core Skills: There are opportunities to develop the Core Skill of *Numeracy* and the Critical Thinking component of the Core Skill of *Problem Solving* at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

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.

Assessment: This Unit could be assessed by a single, holistic end of Unit assessment under supervised conditions.

Higher National Unit specification: statement of standards

Unit title: Fermentation Engineering

Unit code: F3XA 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 operation of major types of bioreactor equipment

Knowledge and/or Skills

- Bioreactor
- Classifications of bioreactor design
- Methods of operation
- Sterilisation, inoculation and aseptic material transfer procedures
- Sensors and control equipment for bioreactor operations
- Downstream processing
- Product recovery operations
- Fermentation industries

Evidence Requirements

Evidence for this Outcome will be provided on a sample basis. Assessment must be conducted under supervised conditions.

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can explain:

- the design and method of operation of at least two classifications of bioreactor equipment from. Static batch and fed-batch fermentations, Stirred tank batch and fed-batch fermentations, Stirred tank batch and fed-batch fermentations for production of yeast extracts or antibiotics, Agricultural fermentations in the ethanol fuel industry, Stirred tank and airlift bioreactors, Hollow fibre bioreactors for the culture of anchored cells.
- procedures for the sterilisation, inoculation and aseptic sampling of bioreactors at least two procedures from autoclave, thermal sterilisation of growth media in batch and continuous fermentations, Sterilisation by filtration, In-situ sterilisation using steam and chemical agents. The explanation must also include the addition and removal of materials under aseptic conditions and approved codes of practice for sterilisation and containment.
- the use of sensors and control equipment in the measurement and control of temperature, pH, oxygen concentration and other process variables during bioreactor operations:
- downstream processing and product recovery operations in the fermentation industries. The explanation must include two operations from solvent extraction, centrifugation, vacuum filtration, ultrafiltration; and hplc and affinity chromatography.

Higher National Unit specification: statement of standards

Unit title: Fermentation Engineering

Assessment Guidelines

Please see Assessment Guidelines for the Unit after Outcome 2

Outcome 2

Select equipment and procedures for fermentation processes

Knowledge and/or Skills

- Batch fermentation processes
- Continuous fermentation processes
- Aerobic fermentation processes
- Sterilisation conditions for growth media and bioreactor equipment
- Mathematical modelling

Evidence Requirements

Evidence for this Outcome will be provided on a sample basis. Assessment must be conducted under supervised conditions.

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- estimate vessel volume, nutrient requirements, service flowrates and product formation rate in batch fermentation and continuous fermentation processes using at least two mathematical models chosen from specific growth rate, doubling time, substrate uptake rate, product formation rate, yield coefficients, maintenance coefficients, the Monod model and other models. Effects of temperature and Ph changes, process optimisation.
- estimate aeration requirements in aerobic fermentation processes using mathematical models. The estimation must include the two-film theory of mass transfer across the gas-liquid boundary, bubble behaviour and mass transfer rates in the airlift bioreactor and the stirred tank bioreactor, and the measurement of oxygen transfer rates in operating bioreactors.
- select appropriate sterilisation conditions for growth media and bioreactor equipment using mathematical modelling of death rates of cells and spores in thermal sterilisation procedures, and the removal rates of cells and spores in filtration sterilisation procedures: first order kinetics, Arrenhius equation, holding time calculations.

Where calculations are performed the candidate 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.

Higher National Unit specification: statement of standards (cont)

Unit title: Fermentation Engineering

Assessment Guidelines for the Unit

Both Outcomes may be assessed by a single supervised assessment in which questions are set requiring descriptions, explanations and calculations relevant to specific types of equipment. The questions may, for example, require descriptions of equipment and explanations of the methods of operation followed by calculation procedures to estimate dimensions of equipment and other process details. In this way, Evidence Requirements for Outcomes 1 and 2 may be assessed simultaneously.

A suitable format may be six questions covering both Outcomes, each requiring approximately 20 minutes to be completed comfortably.

Administrative Information

Unit code: F3XA 34

Unit title: Fermentation Engineering

Superclass category: YC

Original date of publication: August 2008

Version: 01

History of Changes:

Version	Description of change	Date

Source: SQA

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: Fermentation Engineering

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

Outcome 1

The range of manufacturing processes in which the growth of biological cells is the primary activity and the range of bioreactor equipment in which these processes are carried out:

- Static batch and fed-batch fermentations of fruits and grains in the alcoholic beverage industries
- Stirred tank batch and fed-batch fermentations for the production of yeast extracts
- Stirred tank batch and fed-batch fermentations for the production of antibiotics
- Agricultural fermentations in the ethanol fuel industry
- Stirred tank and airlift bioreactors for plant and animal cell suspension cultures
- Hollow fibre bioreactors for the culture of anchored cells

Procedures for the sterilisation of growth media and bioreactor equipment, exclusion of contamination and containment of hazardous organisms:

- The autoclave for the sterilisation of portable equipment
- Thermal sterilisation of growth media in batch and continuous fermentations
- Sterilisation by filtration
- In-situ sterilisation of bioreactor equipment using steam and chemical agents
- Addition and removal of materials under aseptic conditions
- Approved codes of practice for sterilisation and containment

Measurement and control of temperature, pH, oxygen concentration and other variables during bioreactor operations:

- Temperature control using water jackets and cooling coils
- The autoclavable pH electrode and oxygen sensor
- In-situ cell counting, sample counting and foam control

Downstream processing and product recovery operations in the fermentation industries:

- Solvent extraction and centrifugation
- Vacuum filtration and ultrafiltration
- hplc and affinity chromatography.

Higher National Unit specification: support notes (cont)

Unit title: Fermentation Engineering

Outcome 2

Mathematical modelling of biological growth kinetics in batch, fed-batch and continuous fermentation processes:

- specific growth rate, doubling time, substrate uptake rate, product formation rate, yield coefficients, maintenance coefficients, the Monod model and other models
- mass balances in batch, fed-batch and continuous fermentations
- effects of temperature and pH changes, process optimisation

Mathematical modelling of oxygen transfer rates in aerobic fermentation processes:

- the two-film theory of mass transfer across the gas-liquid boundary
- bubble behaviour and mass transfer rates in the airlift bioreactor and the stirred tank bioreactor
- the measurement of oxygen transfer rates in operating bioreactors

Mathematical modelling of death rates of cells and spores in thermal sterilisation procedures, and the removal rates of cells and spores in filtration sterilisation procedures:

- first order kinetics in thermal sterilisation processes
- experimental evidence for the first order model
- the Arrhenius equation, the Del factor and holding time calculations
- kinetics of cell and spore removal in filtration sterilisation processes

Guidance on the delivery and assessment of this Unit

This Unit is designed to be delivered as part of a Group Award providing candidates with technical knowledge and skills for employment in the chemicals, pharmaceutical and beverage manufacturing industries. If possible, it is recommended that the Unit is delivered in the later part of the Group Award, so that candidates have some knowledge of fluid mechanics, heat transfer and mass transfer.

It is recommended that the understanding of principles rather than memorisation of complex formulae is emphasised in the delivery of the Unit. In support of this emphasis, assessments may be appropriate in which candidates have access to their own course materials, provided that the problems set do not appear explicitly in the course materials.

Assessment must be supervised, with no conferring between candidates.

A note on the Evidence Requirements

The Evidence Requirements state that candidates 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 candidates’ 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.

Higher National Unit specification: support notes (cont)

Unit title: Fermentation Engineering

Opportunities for developing Core Skills

There are opportunities to develop the Core Skill of *Numeracy* and the Critical Thinking component of the Core Skill of *Problem Solving* at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Outcome 2's content is substantially mathematical and both components of the Core Skill of *Numeracy* are likely to be utilised and developed during delivery, at level 6.

Open learning

If this Unit is delivered by open or distance learning methods, additional planning resources may be required for candidate support, assessment and quality assurance.

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. Further advice can be found in the SQA document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs* **(www.sqa.org.uk)**.

General information for candidates

Unit title: Fermentation Engineering

This Unit is intended primarily for candidates who are working towards the HNC and HND in Chemical Engineering and Chemical Process Technology.

The Unit is designed to provide you with an overview of fermentation processes in the beverage, chemicals and pharmaceutical industries, knowledge of the equipment in use, and some technical details of its operation. The level of detail should be useful to you if you are employed or expecting to be employed as a process operator in industries using fermentation processes. In addition, the Unit is intended to help you gain entrance to degree studies in Chemical Engineering at second or third year level.

The Unit has two main areas:

- types of bioreactor and methods of operation
- technical details of equipment and process design

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

- describe the manufacture of a range of products obtained from fermentation processes and the range of equipment in use
- perform calculations to estimate the dimensions and operational details of bioreactor equipment

To complete the Unit successfully, you must provide satisfactory responses to a number of questions. These questions will require descriptions and explanations of types of bioreactor equipment and calculations to estimate some aspect of equipment performance. There may be one single assessment period lasting approximately two hours, under supervised conditions.

You will also have the opportunity to develop Core Skills in *Numeracy*, and *Problem Solving* at SCQF level 6. Throughout the Unit, you will perform calculations, manage formulae and perform equations that will help develop the Core Skill of *Numeracy*, and the *Problem Solving* component Critical Thinking at SCQF level 6.