QUALIFICATION HANDBOOK

Level 3 Diploma in Process Technology (0610-30/31/32)

August 2017 Version 2.4

City & Guilds

Qualification at a glance

Subject area	**Process Technology**
City & Guilds number	0610-30, 31, 32
Registration and certification dates	For last dates see the online catalogue/Walled Garden
Age group approved	16-18, 19+
Entry requirements	n/a
Assessment and grading	Pass/Fail
Fast track	Available
Support materials	Centre handbook

Title and level	GLH	TQT	City & Guilds number	Accreditation number
Level 3 Diploma in Process Technology	460	540	0610-30 0610-31 0610-32	600/1066/6

Version and date	Change detail	Section
2.4 August 2017	Added TQT details Deleted QCF	**Qualification at a glance, Structure** **Throughout**
1.1 May 2013	Amend assessment type – Unit 306	**Assessment / Units**
1.2 March 2017	Centre devised guidance	**Assessment**

Contents

1 Introduction

This qualification is aimed at candidates who

- are following Modern Apprenticeship programmes
- require evidence towards the underpinning knowledge of an N/SVQ
- seeking a technical certificate
- wish for career progression within the Process Technology industry

Without evidence of formal qualifications, candidates must be able to demonstrate prior adequate knowledge and experience necessary to complete the course.

This qualification is designed to contribute towards the knowledge and understanding for the N/SVQs in Process Technology Level 2, while containing additional skills and knowledge which go beyond the scope of the National Occupational Standards.

These awards can be used as a technical certificate within a modern apprenticeship scheme.

Structure

To achieve the **Level 3 Diploma in Process Technology (Chemical Processes)**, learners must obtain a minimum total of 60 credits. This is made up of 12 credits from the Core Mandatory Group, plus 24 credits from the Pathway Mandatory Group, plus a minimum of 24 credits from the Optional Group.

Unit accreditation number	City & Guilds unit	Unit title	Credit value
Mandatory			
A/503/0455	301	Mathematics for process industries	6
L/503/0458	302	Communications and information technology in process industries	6

Pathway Mandatory			
R/503/0459	303	Process chemistry in process industries	12
J/503/0460	304	Heat transfer and fluid flow in process industries	12

Optional			
L/503/0461	305	Steam generation and distribution in process industries	6
R/503/0462	306	Distillation in process industries	6
Y/503/0463	307	Evaporation in process industries	6
D/503/0464	308	Crystallisation in process industries	6
M/503/0467	309	Mixing and blending of solids and fluids	6
T/503/0468	310	Water for process industries	6
A/503/0469	311	Principles of process control and fault diagnosis	6
Y/503/0575	312	Principles of compressors and compression technology	6
D/503/0576	313	Drying in process industries	6
H/503/0577	314	Principles of separation of insoluble solids from liquids	6
T/503/0597	315	Size reduction in process industries	6
J/503/0670	316	Gas treatment in process industries	6
M/503/0579	317	Principles of process quality	6
K/503/0581	318	Sampling and laboratory analysis in process industries	6
T/503/0583	319	Special processes in process industries	6

To achieve the **Level 3 Diploma in Process Technology (Petroleum Operations)** learners must obtain a minimum total of 60 credits. This is made up of 12 credits from the Core Mandatory Group, plus 30 credits from the Pathway Mandatory Group, plus a minimum of 18 credits from the Optional Group.

Unit accreditation number	City & Guilds unit	Unit title	Credit value
Mandatory			
A/503/0455	301	Mathematics for process industries	6
L/503/0458	302	Communications and information technology in process industries	6

Pathway Mandatory			
R/503/0459	303	Process chemistry in process industries	12
J/503/0460	304	Heat transfer and fluid flow in process industries	12
A/503/0584	332	Petroleum Technology	6

Optional			
L/503/0461	305	Steam generation and distribution in process industries	6
R/503/0462	306	Distillation in process industries	6
A/503/0469	311	Principles of process control and fault diagnosis	6
Y/503/0575	312	Principles of compressors and compression technology	6
J/503/0670	316	Gas treatment in process industries	6
M/503/0579	317	Principles of process quality	6
K/503/0581	318	Sampling and laboratory analysis in process industries	6
T/503/0583	319	Special processes in process industries	6

To achieve the **Level 3 Diploma in Process Technology (Metal Production)** learners must obtain a minimum total of 54 credits. This is made up of 12 credits from the Core Mandatory Group, plus 12 credits from the Pathway Mandatory Group, plus a minimum of 30 credits from the Optional Group.

Unit accreditation number	City & Guilds unit	Unit title	Credit value
Mandatory			
A/503/0455	301	Mathematics for process industries	6
L/503/0458	302	Communications and information technology in process industries	6

Pathway Mandatory			
M/503/0596	320	Processing metals in process industries	12

Optional			
J/503/0586	321	Iron making and basic oxygen steel making in process industries	6
R/503/0588	322	Electric arc steel making, refining and casting in process industries	6
Y/503/0589	323	Primary working in the steel industry	6
L/503/0590	324	Finishing working processes	6

R/503/0591	325	High technology processing of metals in process industries	6
D/503/0593	326	Metallurgy of iron and steel production	6
Y/503/0592	327	Metallurgy of ferrous metals and alloys	6

Total Qualification Time

Total Qualification Time (TQT) is the total amount of time, in hours, expected to be spent by a Learner to achieve a qualification. It includes both guided learning hours (which are listed separately) and hours spent in preparation, study and assessment.

Title and level	GLH	TQT
0610 Level 3 Diploma in Process Technology	460	540

2 Centre requirements

To offer this qualification, new centres will need to gain both centre and qualification approval. Please refer to the *Centre guide* and *Providing City & Guilds Qualifications* for further information.

Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualification before designing a course programme.

Resource requirements

Centre staffing

Staff delivering this qualification must be able to demonstrate that they meet the following occupational expertise requirements. They must:

- be occupationally competent or technically knowledgeable in the areas for which they are delivering training and/or have experience of providing training. This knowledge must be to the same level as the training being delivered
- have creditable experience of providing training.

Centre staff may undertake more than one role, eg tutor and assessor or internal verifier, but cannot internally verify their own assessments.

Assessors and internal verifiers

Staff assessing or verifying this qualification must be able to demonstrate that they meet the following occupational expertise requirements. They must:

- Have verifiable and relevant current industry experience and competence in the specific area they will be assessing, at or above the level being assessed and evidence of the quality of the occupational experience to ensure the credibility of the assessment judgements. Assessors' and verifiers' experience and competence could be evidenced by:
  - curriculum vitae and references
  - possession of a relevant health and safety qualification
  - appropriate membership of a relevant professional institution
  - continuing professional development (CPD).
- only assess or verify in their acknowledged area of professional competence
- have appropriate knowledge and understanding of the current National Occupational Standards
- actively engage in relevant professional development
- meet the required criteria in the qualification's regulators current regulation documentation.

Centre staff should hold, or be working towards, the relevant Assessor/Verifier (A/V) units for their role in delivering, assessing and verifying this qualification.

Continuing professional development (CPD)

Centres must support their staff to ensure that they have current knowledge of the occupational area, that delivery, mentoring, training, assessment and verification is in line with best practice, and that it takes account of any national or legislative developments.

Candidate entry requirements

City & Guilds does not set entry requirements for this qualification. However, centres must ensure that candidates have the potential and opportunity to gain the qualification successfully.

3 Delivering the qualification

Initial assessment and induction

An initial assessment of each candidate should be made before the start of their programme to identify:

- if the candidate has any specific training needs,
- support and guidance they may need when working towards their qualification].
- any units they have already completed, or credit they have accumulated which is relevant to the qualification.
- the appropriate type and level of qualification.

We recommend that centres provide an induction programme so the candidate fully understands the requirements of the qualification, their responsibilities as a candidate, and the responsibilities of the centre. This information can be recorded on a learning contract.

Support materials

The following resources are available for this qualification:

Description	How to access
Promotional materials – will be available soon	www.cityandguilds.com

Recording documents

Candidates and centres may decide to use a paper-based or electronic method of recording evidence.

City & Guilds endorses several ePortfolio systems. Further details are available at: **www.cityandguilds.com/eportfolios**.

City & Guilds has developed a set of generic *Recording forms* including examples of completed forms, for new and existing centres to use as appropriate.

Recording forms are available on the City & Guilds website.

Although new centres are expected to use these forms, centres may devise or customise alternative forms, which must be approved for use by the external verifier, before being used by candidates and assessors at the centre.

Amendable (MS Word) versions of the forms are available on the City & Guilds website.

4 Assessment

City & Guilds unit	Unit title	Assessment Method
301	Mathematics for process industries	Short Answer
302	Communications and information technology in process industries	Assignment
303	Process chemistry in process industries	Short-Answer
304	Heat transfer and fluid flow in process industries	Short-Answer
305	Steam generation and distribution in process industries	Short Answer
306	Distillation in process industries	Centre Devised
307	Evaporation in process industries	Centre Devised
308	Crystallisation in process industries	Centre Devised
309	Mixing and blending of solids and fluids	Centre Devised
310	Water for process industries	Centre Devised
311	Principles of process control and fault diagnosis	Short Answer
312	Principles of compressors and compression technology	Short Answer
313	Drying in process industries	Centre Devised
314	Principles of separation of insoluble solids from liquids	Centre Devised
315	Size reduction in process industries	Centre Devised
316	Gas treatment in process industries	Centre Devised
317	Principles of process quality	Centre Devised
318	Sampling and laboratory analysis in process industries	Centre Devised
319	Special processes in process industries	Centre Devised
320	Processing metals in process industries	Multiple-Choice
321	Iron making and basic oxygen steel making in	Centre

	process industries	Devised
322	Electric arc steel making, refining and casting in process industries	Centre Devised
323	Primary working in the steel industry	Centre Devised
324	Finishing working processes	Centre Devised
325	High technology processing of metals in process industries	Centre Devised
326	Metallurgy of iron and steel production	Centre Devised
327	Metallurgy of ferrous metals and alloys	Centre Devised
332	Petroleum Technology	Short-Answer

Centre set and marked assessments

City & Guilds has provided separate guidance for writers of centre based assessments which should be read in conjunction with this document, entitled, **'*GM1 - Developing centre devised assessments –*** *guidance for centre based assessment writers*'.

A set of generic recording forms is also provided as follows:

- Assessment tasks (AD1)
- Assessment grading criteria (AD2)
- Assessment sign off form (AD3)
- Evidence recording form (GF1)
- Assessment unit front and mark sheet (GF2)
- Assessment task front sheet (GF3)
- Assessment unit mark sheet (GF4)
- Assessment feedback and action plan form (GF5)
- Qualification assessment tracking form (GF6)
- Group assessment tracking form (GF7)

A full explanation of the use of these forms can be found in the centre devised assessment writing guidance. All of this material is available to download from the City & Guilds website. at **http://www.cityandguilds.com/delivering-our-qualifications/centre-development/quality-assurance/quality-assurance-documents**

5 Units

Structure of units

These units each have the following:

- City & Guilds reference number
- unit accreditation number
- title
- level
- credit value
- unit aim
- relationship to NOS, other qualifications and frameworks
- endorsement by a sector or other appropriate body
- information on assessment
- learning outcomes which are comprised of a number of assessment criteria
- notes for guidance.

Unit 301 Mathematics for process industries

Unit reference:	**A/503/0455**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room) Level 3 Metal Processing and Allied Operations.
Assessment requirements	Short Answer
Aim	This unit is designed to give candidates the mathematical skills and knowledge needed for a general understanding of the unit operations and processes throughout the process industries.

Learning outcome	**The learner will:**
1. Understand numerical approximations and unit conversion tables	
Assessment criteria	
The learner can: 1.1 calculate numbers to specified figures or decimal places. 1.2 calculate approximations and estimations 1.3 construct mathematical tables • imperial units to metric units and vice versa • Fahrenheit temperatures to Celsius and vice versa • mass and volume using density values • volumes and temperatures.	

Learning outcome	The learner will:
2. Be able to calculate areas, volumes and flow rates	
Assessment criteria	
The learner can: 2.1 calculate areas of shapes • triangle • square • rectangle • parallelogram • circle • trapezium • composite shapes. 2.2 calculate volumes • cylindrical vessels • spherical vessels • pipelines • metal in pipes • composite solids 2.3 calculate flow rates	

Learning outcome	The learner will:
3. Understand statistical data	
Assessment criteria	
The learner can: 3.1 extract data from practical work or technical publications. 3.2 interpret data sources 3.3 tally diagrams • histograms • pie charts • bar charts • graphs • pictographs. 3.4 describe the differences between samples and populations. 3.5 define frequencies and relative frequencies 3.6 interpret data summarised in tables, charts and diagrams.	

Learning outcome	The learner will:
4. Be able to apply the basic rules of algebra to solve problems	
Assessment criteria	
The learner can: 4.1 state rules of indices • the concept of power and base • positive, negative and fractional indices • division and multiplication of indices. 4.2 evaluate numerical expressions containing combined positive, negative and fractional indices. 4.3 convert numbers to standard forms. 4.4 apply addition, subtraction, multiplication and division to numbers in standard forms. 4.5 apply rules of algebra to problems • add, subtract, multiply and divide algebraic terms • use brackets • identify common factors and factorise • multiply expressions in brackets by a number, symbol or another expression in brackets. 4.6 use algebraic expressions 4.7 solve equations with one unknown 4.8 solve simultaneous equations 4.9 evaluate formulae of forms • $V = IR$; $A = \pi r^2$; $V = \frac{\pi r^2 h}{3}$ • $R = R_1 + R_2 + R_3$; $A = 2\pi r^2 + 2\pi rh$	

Unit 302 Communications and information technology in process industries

Unit reference:	**L/503/0458**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room) Level 3 Metal Processing and Allied Operations. It also contributes to providing evidence for Information Technology and Communications at Key Skills Level 3.
Assessment requirements	Assignment
Aim	This core unit is designed to improve candidates' communication and IT skills in a technical context. It also provides a basis for the development of these skills to a higher level.

Learning outcome	**The learner will:**
1. Be able to produce technical reports on industrially relevant issues	
Assessment criteria	
The learner can: 1.1 apply stages in preparing reports • defining the problem • gathering data • analysing the results • drawing conclusions • sketching an outline report • revising the drafts • producing the final report. 1.2 collect information from different sources • production or machine records	

- work colleagues
- technical literature
- CD-Rom
- internet

1.3 prepare information into coherent formats for reports.

1.4 maintain the focus of technical reports

- objectivity (ie lacking in partiality, prejudice and bias)
- brevity
- clarity.

1.5 identify structures of formal reports

- title
- contents
- summary
- introduction
- discussion, procedure or method
- findings or results
- conclusions
- appendices
- references.

1.6 use graphs, diagrams and pictures in reports

1.7 use appropriate language in documents

Learning outcome	**The learner will:**
2. Be able to use a word-processing package to develop a technical report that includes tabular, graphical, symbolic and pictorial information	
Assessment criteria	

The learner can:

2.1 implement tables of contents using automated features of packages.

2.2 create documents to house-styles

- font size and types
- headings and sub-headings
- paragraph numbering
- page layout.

2.3 insert graphs, tables and pictures

2.4 design template documents.

2.5 insert mathematical symbols using equation editors.

2.6 insert headers and footers

- page titles
- page numbers
- date
- version number
- file name.

2.7 apply software spelling and grammar checks to texts.

Learning outcome	The learner will:
3. Be able to obtain, organise and store information in an electronic form	
Assessment criteria	
The learner can: 3.1 describe the meaning of relational and logical operators • less than • more than • AND • OR • NOT. 3.2 describe how two computers are connected over the internet. 3.3 insert hyperlinks into documents or spreadsheets. 3.4 insert downloaded files and selected information into other documents. 3.5 perform importing and exporting of files between software packages • between a spreadsheet and a word-processor • between a database and a spreadsheet. 3.6 describe the hierarchy of data storage on hard discs • directory • sub-directory • file structures	

Unit 303 Process chemistry in process industries

Unit reference:	**R/503/0459**
Level:	3
Credit value:	10
GLH:	It is recommended that **80** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Short Answer
Aim	This unit extends the basic knowledge gained in the Level 2 studies and provides a deeper insight and understanding of the chemical principles involved in the manufacturing processes of the chemical industry.

Learning outcome	**The learner will:**
1. Understand the structure and properties of elements, mixtures, compounds, crystals and alloys	
Assessment criteria	
The learner can: 1.1 explain terms used in atomic and molecular theories • atomic number • mass number • isotope. 1.2 determine the atomic number and atomic mass given the number of protons and neutrons in atoms. 1.3 describe the arrangement of electrons in atoms • concept of shell structure • numbers of electrons in each shell: 2, 8, 18 1.4 state configurations/noble gas structures. 1.5 explain how electronic configuration relates to valency, oxidation number and reactivity of elements. 1.6 describe the structure of the periodic table • the concept of groups	

- the concept of period
- the concept of metals and non-metals.

1.7 predict properties of elements using the periodic table

- within a group
- along a period
- diagonal relationships.

1.8 explain the formation of molecules from elements

- ionic bonding
- covalent bonding.

1.9 describe differences between the general properties of ionic and covalent compounds

- melting and boiling points
- solubility in water
- crystal structure
- electrical conductivity.

1.10 describe the differences between elements, compounds and mixtures.

1.11 describe structures of crystalline and non-crystalline materials

- simple cubic lattice
- body-centred cubic lattice
- tetrahedral
- allotropy.

1.12 describe common crystalline and non-crystalline materials

- sodium chloride
- cesium chloride
- zinc sulphide
- carbon and sulphur.

1.13 describe the metallic bond and differences between metals and non-metals.

1.14 explain physical properties of metals

- hardness
- tensile strength
- ductility
- brittleness
- malleability
- elasticity
- electrical and thermal conductivity
- density.

1.15 explain the formation of alloys.

1.16 describe the composition, properties and applications of metals and alloys used in the chemical industry

- iron and its alloys
- aluminium and its alloys
- copper and its alloys
- zinc
- lead
- nickel.

1.17 describe how the metals and alloys react with process materials and environments

- reactions with weak and strong acids and alkalis
- reactions with air, oxygen, water, acid and alkali gases.

Learning outcome	The learner will:
2. Understand the importance of chemical equilibrium and energy changes in reactions involved in manufacturing processes	
Assessment criteria	
The learner can: 2.1 explain the meaning of the term reversible reaction. 2.2 explain the meaning of the term chemical equilibrium. 2.3 explain the use of the Le Chatelier principle in predicting the effect of changes in conditions on equilibrium • changes in temperature • changes in pressure • changes in reactant concentration • changes in product concentration • presence of a catalyst. 2.4 predict effects of changes of conditions on the yield of industrial products using the Le Chatelier principle • ammonia • sulphur trioxide • methanol • ethanol. 2.5 explain the meaning of the term rate of reaction. 2.6 describe the effect of changes in conditions on rates of reaction • changes in temperature • changes in concentration of reactants • the physical state of reactants • presence of a catalyst. 2.7 explain how catalysts affect rates of reaction • positive and negative catalysts (inhibitors) • homogeneous catalysts • heterogeneous catalysts • auto-catalysts • catalyst promoter. 2.8 describe catalysts used in common industrial processes. 2.9 explain what is meant by enthalpy 2.10 state the units and symbol used for enthalpy 2.11 explain the sign convention for enthalpy change. 2.12 explain the first law of thermodynamics. 2.13 explain types of enthalpy change • heat (enthalpy) of reaction • heat (enthalpy) of combustion • heat (enthalpy) of formation • heat (enthalpy) of neutralisation. 2.14 explain exothermic and endothermic reactions. 2.15 explain the use of Hess's law. 2.16 calculate enthalpy changes for simple reactions	

Learning outcome	The learner will:
3. Understand the processes involved in electrolysis and galvanic corrosion	
Assessment criteria	
The learner can: 3.1 define terms used in electrochemistry • anode, cathode, electrolyte • anion, cation • electrolysis • weak and strong electrolytes • dissociation. 3.2 explain the direction of migration of ions during electrolysis under an applied emf. 3.3 explain the process of electrolysis in terms of electron loss (oxidation) or electron gain (reduction). 3.4 explain the electrolysis of simple electrolytes • fused sodium chloride • aqueous sodium chloride • acidified water • copper sulphate solution. 3.5 describe industrial uses of electrolysis • extraction/refining of metals • production of sodium hydroxide and chlorine • anodising aluminium • electroplating • electropolishing. 3.6 explain Faraday's laws of electrolysis. 3.7 perform simple calculations using Faraday's laws. 3.8 explain the ways in which corrosion of metals can occur • contact with water, oxygen, air, atmospheric gases and industrial pollutants • contact with other metals and an electrolyte to produce a corrosion cell. 3.9 describe the process of corrosion by galvanic action. 3.10 identify the anode and cathode of corrosion cells formed by metals in contact. 3.11 predict the metal which will corrode preferentially for metals in contact with electrolytes. 3.12 define the terms sacrificial cathode and sacrificial anode. 3.13 describe methods of corrosion protection • use of paints, coatings, etc • use of external emf • use of sacrificial anodes and cathodes • zinc and tin coatings.	

Learning outcome	The learner will:
4. Know of the structure, classifications and properties of carbon compounds and polymers	
Assessment criteria	
The learner can: 4.1 identify differences between empirical and molecular formulae. 4.2 describe structural isomerism • butane • pentane. 4.3 classify carbon compounds according to functional groups • monohydric alcohols • monocarboxylic acids • halides (alkyl and acyl) • amines • amides • aldehydes • ketones • nitro compounds • azo compounds • esters. 4.4 state their general formulae of functional groups 4.5 describe organic chemistry reactions • substitution • addition • hydrogenation • esterification • halogenation • nitration • sulphonation • oxydation/reduction • hydrolysis. 4.6 define the terms polymer and co-polymer. 4.7 identify differences between natural and synthetic polymers and rubbers. 4.8 identify differences between thermosetting resins and thermoplastics. 4.9 describe industrial production of polymers • addition polymers; polyethene, polypropene • condensation polymers; polyamides and polyesters.	

Unit 304 Heat transfer and fluid flow in process industries

Unit reference:	**J/503/0460**
Level:	3
Credit value:	12
GLH:	It is recommended that **80** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Short Answer
Aim	This unit provides the essential knowledge required for an understanding of the way in which the principles of heat transfer are applied to problems associated with the heating and cooling of process fluids in industry and the way in which the basic principles of fluid flow are used to solve problems associated with the transport and control of fluids in pipeline systems.

Learning outcome	**The learner will:**
1. Understand the principles of heat transfer and energy conservation	
Assessment criteria	
The learner can: 1.1 explain the modes of heat transfer • conduction • convection • radiation. 1.2 explain factors that determine rates of heat transfer by conduction • area through which heat is transferred • thickness of material • temperature difference across the medium • thermal conductivity of material. 1.3 calculate steady state heat transfer through simple layers of materials using Fourier's law 1.4 explain why the theoretical rate of heat transfer, under practical	

conditions, will be resisted and reduced

- fouling deposits on heat transfer surfaces
- layers of lagging material
- static layers of fluid on heat transfer surfaces.

1.5 describe differences between natural and forced convection and their relative advantages and disadvantages in heat exchange systems.

1.6 explain factors that determine rates of heat transfer by natural and forced convection

- fluid density
- fluid viscosity
- temperature difference
- type of flow.

1.7 explain factors that determine rates of heat transfer by radiation

- surface area
- surface temperature
- temperature of surroundings
- nature of surface (emissivity/absorptivity).

1.8 explain the importance of restricting heat losses from hot surfaces of industrial processing equipment

- energy conservation
- safety considerations

1.9 improve working conditions.

1.10 explain factors that affect rates of heat loss from hot surfaces by convection and radiation

- surface area and position
- temperature difference between surface and surroundings
- nature of surface
- nature of fluid in contact with surface
- rate of flow of fluid in contact with surface.

1.11 describe methods of minimising heat losses from hot surfaces

- use of lagging
- use of surfaces which reduce radiation
- air gaps and vacuum
- restriction of convection currents.

1.12 explain the insulation properties of common lagging materials

- magnesia
- slag wool
- fibre glass
- aluminium foil, sheet and paint.

Learning outcome	The learner will:
2. Understand the basic principles of heat transfer to the construction, operation and efficient use of heat exchange equipment	
Assessment criteria	

The learner can:

2.1 describe the construction and operating principles of heat exchangers
- double pipe
- shell and tube, single and multiple pass
- hairpin types
- floating head types
- air fin types
- reboilers.

2.2 identify differences between the functions of various types of heat exchange equipment
- heaters
- coolers
- condensers
- reboilers
- pre-heaters
- space heaters
- boilers and waste heat boilers.

2.3 explain the effects of scaling, fouling and corrosion on the efficient operation of heat exchangers.

2.4 explain the need for regular cleaning of heat exchange equipment.

2.5 identify common heat exchange fluids
- water, steam, superheated steam
- oils
- gases and liquefied gases
- molten salts and molten metals
- solutions.

2.6 describe the advantages, disadvantages and applications of heat exchange fluids

2.7 explain principles of open evaporative and forced air water cooling systems
- cooling by evaporation
- windage losses
- effect of ambient humidity and temperature.

2.8 describe the treatment and management of water used in water cooling systems
- algae and bacteria removal
- removal of dissolved solids
- removal of suspended solids
- pH control.

2.9 describe the construction, operation and applications of cooling towers and their ancilliary equipment
- natural draught
- forced draught
- induced draught
- forced air process water cooling systems.

2.10 explain basic principles of refrigeration
- gas liquefaction

- adiabatic and isothermal expansion/contraction
- Joule-Thompson effect.

2.11 explain the function of components of a vapour compression refrigeration system

- compressor
- condenser
- expansion valve
- evaporator
- oil filter.

2.12 explain the function of primary and secondary refrigerants

2.13 describe the desirable properties of primary and secondary refrigerants

Learning outcome	**The learner will:**
3. Know the health and safety hazards associated with heat transfer operations and the precautions which will minimise them	
Assessment criteria	

The learner can:

3.1 describe methods of minimising hazards of hot surfaces

- use and maintenance of lagging
- use of recommended Personal Protection Equipment.

3.2 describe precautions necessary to minimise hazards associated with heat exchange fluids

- corrosion and erosion of construction materials
- toxicity and flammability
- effects of thermal radiation.

3.3 describe precautions necessary to minimise hazards associated with refrigeration

- cold burns
- toxic, corrosive and flammable nature of refrigerants
- mechanical noise.

Learning outcome	**The learner will:**
4. Understand the characteristics and basic principles of fluid flow	
Assessment criteria	

The learner can:

4.1 identify factors which affect the flow of fluids in pipes and tubes

- fluid viscosity
- fluid temperature
- pressure head and pressure difference
- cross-sectional area of pipe/tube
- fluid density
- bends, contractions and constrictions in pipes
- obstructions and fittings in pipework.

4.2 explain the significance of factors which affect the flow of fluids

4.3 explain the significance of Reynolds numbers in pumping and heat transfer operations.

4.4 calculate the Reynolds number to predict flow type

- laminar (streamlined) flow
- turbulent flow
- transitional flow.

4.5 describe differences between Newtonian and non-Newtonian flow.

4.6 explain the importance of terms used in Bernouilli's equation

- kinetic head
- pressure head
- potential head
- total head.

4.7 use Bernoulli's equation to solve problems relating to fluids flowing in pipes

- for changes in height
- for changes in cross-sectional area.

4.8 explain how Bernoulli's equation is modified before it is used to solve practical design problems

- allowances for fluid and pipe wall friction
- allowances for pipe fittings
- concept of friction factor.

4.9 calculate power and energy requirements for pumping fluids against pressure and head of liquids.

4.10 explain the concept of optimum pipe diameter.

4.11 describe the process of cavitation

4.12 explain the effect of cavitation on the efficiency of a pump.

4.13 explain the meaning of the term net positive suction head.

4.14 explain the meaning of the terms pump capacity and volumetric efficiency.

Learning outcome	**The learner will:**
5. Understand the basic principles of fluid flow to the construction and operation of systems for transporting and controlling fluids in pipeline systems	
Assessment criteria	

The learner can:

5.1 describe the construction, operation and application of centrifugal (persuasive) pumps

- single and multi-stage
- series and parallel arrangements.

5.2 describe the construction, operation and application of positive displacement pumps

- reciprocating; piston, plunger, diaphragm
- single and double action pumps
- rotors; gear, vane, lobe, screw.

5.3 explain factors which influence the choice of pumps for particular duties

- physical and chemical properties of fluid
- flow rate required
- pressure head required
- plant layout
- capital/maintenance costs
- hazards and safety considerations.

5.4 justify the selection of pumps for specific duties.

5.5 explain the need for pump drive shaft seals

- safety
- leakages/losses.

5.6 describe the construction and application of shaft seals

- simple stuffing box/packed seal
- lantern ring
- mechanical seal
- liquid and gas seals.

5.7 explain the need for lubrication of shaft seals, bearings and other moving parts

5.8 describe equipment used for lubrication of seals and bearings

- oil pots
- slinger/oil rings
- pumped lubrication.

5.9 describe the construction, operation and application of pumps used for transferring gases

- reciprocating piston types
- rotary blowers - vane type, lobe type
- centrifugal blowers
- radial flow fans
- axial flow fans
- multi-stage units.

5.10 describe methods of preventing deposition of solid material in pipelines

- steam tracing, electrical tracing
- steam/water jackets.

5.11 describe methods of cleaning pipelines

- high pressure jet cleaning
- rotary brushes
- pigging
- use of solvents.

Learning outcome	The learner will:
6. Know the health and safety hazards associated with the transfer of fluids in pipework systems and the precautions necessary to minimise them	
Assessment criteria	
The learner can: 6.1 identify hazards associated with the transfer of flammable toxic or corrosive materials • within the plant • between tanker and storage tank. 6.2 describe precautionary procedures to prevent hazards arising • use of non-spark tools • use of protective clothing • correct works procedures • earthing • water cooling • use of anti-static additives. 6.3 describe devices used to minimise dangers due to sudden excessive build-up of pressure in pipelines • bursting discs • pressure relief valves. 6.4 describe safe start-up and shutdown procedures for centrifugal and positive displacement pumps • valve sequences • suction; priming/draining of centrifugal pumps, venting. 6.5 identify hazards associated with the cleaning of pipes • toxicity of fluid • static: explosion/fire • pressure build-up • pyrophoric deposits.	

Unit 305 Steam generation and distribution in process industries

Unit reference:	**L/501/0461**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Short Answer
Aim	This unit provides the essential knowledge required for an understanding of the generation and distribution of steam as an essential service to industry.

Learning outcome	**The learner will:**
1. Understand the theory, principles and practice of steam generation and distribution	
Assessment criteria	
The learner can: 1.1 describe heat transfer processes associated with boiler plants • radiation from heat source (burner) • convection within liquids and gases • conduction through tube walls, films and deposits • heat losses from hot surfaces and waste gases. 1.2 explain processes of converting water to superheated steam • sensible heat • latent heat • boiling points • effect of pressure. 1.3 describe the origins of fossil fuels • coal-based fuels • petroleum-based fuels • natural gas.	

1.4 describe properties of coal-based fuels used in boiler plants
- moisture, ash and volatile matter
- carbon and hydrogen percentages
- sulphur content
- heating value (calorific value)
- article size.

1.5 describe properties of fuel oils used in boiler plants
- carbon and hydrogen percentages
- sulphur content
- ash content
- heating value (calorific value)
- viscosity.

1.6 describe properties of gaseous fuels used in boiler plants
- carbon, hydrogen and carbon monoxide content
- sulphur content
- heating value (calorific value).

1.7 compare the properties of coals, oils and gaseous fuels with respect to their use as heating mediums in boiler plants
- heating value (calorific value)
- ash and sulphur content
- particle size/physical state
- economics of use
- control of combustion process.

1.8 calculate combustion air requirements for natural gas
- stoichiometric requirements
- excess air.

1.9 explain the use of steam tables

1.10 extract simple information from steam tables
- temperature/pressure relationship
- enthalpy (saturated vapour)
- latent heat
- specific volume.

1.11 identify differences between forms of steam
- wet steam
- dry steam
- superheated steam
- flash steam
- low pressure steam
- high pressure steam.

Learning outcome	**The learner will:**
2. Know the construction, operation and control of equipment used in industry for generating and distributing high and low pressure steam	
Assessment criteria	

The learner can:

2.1 explain the main reasons for generating steam
- power generation
- heating.

2.2 identify types of boiler feedwater
- treated water

- condensate return/recovery.

2.3 explain desirable properties of boiler feed water

- de-ionised
- de-aerated
- negligible suspended solids
- pH slightly alkaline
- negligible silica
- bacteria free.

2.4 explain methods of water treatment

- ion exchange
- deaeration
- use of chemical additives.

2.5 describe the construction and operation of shell boilers (fire tube boilers)

- Lancashire
- two-pass economic (wet back and dry back)
- modern packaged.

2.6 describe the construction and operation of water tube boilers.

2.7 explain the functions and operating principles of components of water tube boilers

- superheaters
- economisers
- combination air preheaters
- water drums
- steam drums.

2.8 compare characteristics and performance of shell boilers and water tube boilers

- thermal efficiency
- maintenance costs
- duty/application
- output of steam.

2.9 state functions of components of steam distribution systems

- boiler
- steam traps
- air vents
- valves
- pipework
- lagging.

2.10 explain how the efficiency of steam production and distribution systems can be maintained

- good combustion control and burner maintenance
- regular cleaning/maintenance of shells, tubes and all heat transfer surfaces
- regular inspection/maintenance of steam traps, economisers and preheaters
- regular inspection/maintenance of lagging.

Learning outcome	The learner will:
3. Know the function of essential ancillary equipment required by boiler plant	
Assessment criteria	
The learner can: 3.1 state the function of types of valve necessary for safe distribution of steam • relief • check • globe • pressure reducing • butterfly. 3.2 describe the construction, operation and characteristics of steam traps • mechanical • thermostatic • thermodynamic. 3.3 describe techniques used to ensure good mixing of combustion air and fuel • atomisation (oils) • use of fluidised beds (coals) • use of powdered (pulverised) coals. 3.4 describe the construction, operating principles and characteristics of equipment used to burn coals in boiler plants • chain and travelling grate stokers • pulverised fuel burners • fluidised bed burners. 3.5 describe the construction, operating principles and characteristics of oil burners • pressure jet burners • blast burners (air and steam atomised) • rotary cup burners. 3.6 describe the construction, operating principles and characteristics of gas burners • aerating (high and low pressure) • non-aerating • dual fuel. 3.7 outline start up and shutdown procedures for boiler plants • burning gases • burning oils • burning coals.	

Learning outcome	The learner will:
4. Know of the safety hazards associated with the production and distribution of steam and the precautions necessary to minimise them	
Assessment criteria	
The learner can: 4.1 describe precautions to minimise hazards associated with storage, transfer and handling of solid, liquid and gaseous fuels • explosions due to pulverised fuel • flammable liquids and vapours from fuel oil leaks • explosive hazards from gas leaks • hazards due to static electricity. 4.2 explain the need for strict start up and shutdown procedures • water supply control • combustion air supply control • fuel supply control • temperature and pressure control. 4.3 explain the need for combustion controls and use of excess air • to avoid atmospheric pollution • to prevent carbon deposits in system • to minimise explosions in outlet flue systems. 4.4 explain how regular cleaning and maintenance of tubes and heat exchange surfaces can reduce the possibility of boiler explosions. 4.5 describe precautions to minimise hazards associated with the distribution of steam • faulty pressure relief valves • faulty water level indicator • poorly maintained lagging • static electricity • faulty steam traps • corrosion and erosion.	

Unit 306 Distillation in process industries

Unit reference:	**R/503/0462**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Centre Devised
Aim	This unit provides the essential knowledge required for an understanding of the fundamentals of distillation technology and practice as carried out by the petrochemical industry to obtain products from raw materials.

Learning outcome	**The learner will:**
1. Understand the theory, principles and practice of separation of liquid mixtures by distillation techniques	
Assessment criteria	
The learner can: 1.1 explain terminology used in distillation theory • vapour pressure • saturated vapour pressure • partial pressure • total pressure. 1.2 explain the effect of changes in temperature on vapour pressure of liquids. 1.3 plot vapour pressure/temperature diagrams • pure liquid • binary mixtures. 1.4 interpret vapour pressure/temperature diagrams 1.5 relate vapour pressures to the boiling points of liquids • pure liquids • miscible liquid mixtures	

- immiscible liquid mixtures.

1.6 explain the use of Dalton's law of partial pressures.

1.7 explain how Raoult's law can be used to calculate the total vapour pressure of ideal binary liquid mixtures.

1.8 identify differences between ideal and non-ideal liquid mixtures.

1.9 explain the effects of boiling point differences on the separation of miscible liquids.

1.10 construct vapour pressure/composition diagrams for binary mixtures

- ideal mixtures
- non-ideal mixtures (azeotropes).

1.11 interpret vapour pressure/composition diagrams for binary mixtures

1.12 construct boiling point/composition diagrams for binary mixtures

- ideal mixtures
- non-ideal mixtures (azeotropes).

1.13 interpret boiling point/composition diagrams for binary mixtures

1.14 use boiling point/composition diagrams to estimate the number of theoretical stages for fractional distillation processes.

1.15 explain the principles of distillation techniques

- simple batch
- flash
- continuous fractionation
- batch fractionation
- azeotropic
- steam
- vacuum
- pressure.

Learning outcome	**The learner will:**
2. Understand the construction, operation and application of distillation equipment used in industry	
Assessment criteria	

The learner can:

2.1 describe the construction, operation and applications of types of plate columns

- bubble cap
- sieve trays
- valve trays
- shower trays.

2.2 explain the function of components of plate columns

- plates/trays
- weirs
- downcomers.

2.3 compare advantages and disadvantages of types of distillation plates

- weight
- cost
- installation
- liquid/vapour handling capacity
- plate efficiency

- pressure drop across plate
- entrainment
- dumping.

2.4 describe the construction, operation and application of packed columns.

2.5 describe types of column packing

- Raschig rings
- Lessing rings
- Berl saddles
- interlox saddles
- Pall rings.

2.6 compare efficiency, cost and operational problems of packed and plate columns

- corrosion
- foaming
- fouling
- heat evolution
- liquid hold up
- pressure drop.

2.7 explain operating problems associated with plate and packed columns

- variations in temperature
- variations in pressure
- variations in composition
- variations in reflux ratio
- boil up.

2.8 explain factors which affect the economics of column operation

- capital costs
- operational costs
- maintenance.

Learning outcome	**The learner will:**
3. Understand the function of ancillary equipment required by distillation plant	
Assessment criteria	

The learner can:

3.1 describe the construction, operation and application of ancillary equipment

- reboilers
- condensers and coolers
- reflux ratio dividers
- pipe furnaces and pre-heaters
- vacuum and pressure equipment.

3.2 explain how process variables are controlled using ancillary equipment

- column temperature
- feed rate
- reflux ratio
- feed temperature
- column pressure
- product analysis.

Learning outcome	The learner will:
4. Know the safety hazards associated with distillation processes and the precautions necessary to minimise them	
Assessment criteria	
The learner can: 4.1 describe precautions to minimise hazards associated with distillation plant • corrosion • explosion • implosion • toxicity of materials • flammability of materials • overheating and auto-ignition • pressure surge • static electricity • spillages and leaks. 4.2 describe the functions of special chemicals used to reduce operational hazards • anti-foaming agents • corrosion inhibitors	

Unit 307 Evaporation in process industries

Unit reference:	**Y/503/0463**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture
Assessment requirements	Centre Devised
Aim	This unit provides the essential knowledge required for an understanding of the basic principles, techniques and technology of evaporation operations carried out in the chemical industry to produce products or intermediate products.

Learning outcome	**The learner will:**
1. Understand the scientific principles and practice involved in efficient evaporation operations	
Assessment criteria	
The learner can: 1.1 explain the purposes of evaporation operations in process industries • to produce concentrated product and intermediate products • to produce concentrated feed for crystallisers • to remove/recover valuable solvents. 1.2 explain the importance of specific heat capacity and specific latent heat in evaporation processes. 1.3 describe how heat is transferred from thermal fluids to process fluids in evaporation processes • conduction • natural convection • forced convection. 1.4 explain factors which affect efficient transfer of energy • surface area for heat transfer • temperature difference between thermal and process fluids • degree of turbulence (Reynolds number). 1.5 explain factors that will reduce thermal efficiency • scale and other deposits • stagnant fluid films	

- poor turbulence
- heat losses from hot unlagged surfaces.

1.6 explain the importance of overall heat transfer coefficient for evaporation equipment

1.7 explain the importance of residence time.

1.8 explain the effects of pressure changes on boiling and evaporation processes.

1.9 describe the principles involved in flash evaporation.

Learning outcome	**The learner will:**
2. Know the construction, operation, control and application of equipment used in industry for evaporation processes	

Assessment criteria

The learner can:

2.1 describe the construction, operation and application of evaporation equipment

- short tube evaporators (vertical and horizontal)
- forced circulation (internal and external calandria)
- long tube evaporators (climbing film, falling film, scraped surface falling film)
- plate evaporators.

2.2 identify differences between batch and continuous operation of evaporators

2.3 state relative advantages and disadvantages batch and continuous operation

2.4 explain factors that determine the choice of evaporator

- relative advantages/disadvantages
- throughput
- equipment cost
- product specification.

2.5 explain the principles and applications of evaporation under vacuum

- processing heat-sensitive materials
- use of low grade heat.

2.6 explain the principles of multiple effect evaporation

2.7 state advantages of multiple effect evaporation.

2.8 describe methods of feeding multiple effect evaporators and their relative advantages and disadvantages

- forward feed
- backward feed
- parallel feed
- mixed feed.

2.9 explain problems affecting the efficiency of evaporation

- erosion and corrosion
- salting, scaling, fouling
- foaming, splashing, entrainment
- venting
- temperature of feed
- viscosity changes
- decomposition during heating.

2.10 describe the construction, operation and application of heat

recovery systems associated with evaporation processes

- feed preheaters
- condensate flash systems
- flash evaporation
- vapour recompression.

2.11 explain why process variables associated with evaporation operation must be measured and controlled

- feed flow rate
- feed temperature
- feed and product concentration
- thermal fluid temperature
- vacuum/pressure
- fluid level.

2.12 describe the measurement and control of process variables

2.13 state possible causes and corrective actions for evaporator process faults

- product solution too weak or too strong
- loss of vacuum
- premature evaporation
- excessive entrainment
- temperature/pressure variation
- blockages
- poor venting.

Learning outcome	**The learner will:**
3. Understand the function of essential ancillary equipment used in evaporation operations	
Assessment criteria	

The learner can:

3.1 state the types of pump used on evaporators

- centrifugal
- axial flow
- vacuum pumps and steam ejectors.

3.2 select pumps for use on evaporation duties

3.3 state applications for valves used on evaporators

- air-operated globe and diaphragm valves
- pressure relief and pressure reducing valves
- steam traps.

3.4 describe the construction, operation and application of agitators used in evaporators

- axial propeller types
- radial propeller (semi-shrouded).

3.5 describe the construction, operation and application of vapour condensers

- surface types
- contact types.

3.6 describe the construction, operation and application of entrainment separators

- momentum types
- cyclonic types.

Learning outcome	The learner will:
4. Know of the safety hazards associated with evaporation processes and the precautions necessary to minimise them	
Assessment criteria	
The learner can: 4.1 describe precautions necessary to minimise hazards associated with the operation of evaporation equipment • hot surfaces • steam and hot thermal fluids • implosions and explosions of vacuum and pressure systems • foaming, splashing and entrainment • leaks • tube blockages • thermal decomposition • corrosion • nature of solvent and solution.	

Unit 308 Crystallisation in process industries

Unit reference:	**D/503/0464**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture.
Assessment requirements	Centre Devised
Aim	This unit provides the essential knowledge required for an understanding of the fundamentals of crystallisation technology and practice as carried out in industry to obtain products in crystal form.

Learning outcome	**The learner will:**
1. Understand the principles behind the production of crystals from saturated solutions, and how they affect the techniques of crystallisation	
Assessment criteria	
The learner can: 1.1 state units of solubility. 1.2 explain how solubility varies with temperature. 1.3 explain the meaning of terms used in crystallisation • unsaturated solution • saturated solution • supersaturated solution. 1.4 draw solubility curves 1.5 identify key features of solubility curves • unsaturated region • saturation curve • supersaturated region • metastable region. 1.6 describe how crystal nuclei form and grow from supersaturated solutions. 1.7 explain the principles and application of 'seeding'. 1.8 describe principles involved in the production of supersaturated solutions	

- evaporation
- cooling
- evaporative cooling.

1.9 explain factors which affect the formation, size and shape of crystals

- convection currents in liquor
- concentration of liquors
- solubility of solute at different temperatures
- type of crystalliser.

1.10 perform simple mass and energy balances on single effect evaporators.

Learning outcome	The learner will:
2. Understand the construction, operation, control and applications of industrial crystallisation equipment	
Assessment criteria	

The learner can:

2.1 explain purposes of crystallisation

2.2 extract soluble solid from solution

- purification
- production of crystals of desired specified size and size range.

2.3 identify differences between batch and continuous crystallisers.

2.4 describe the construction, operation and application of cooling crystallisers

- trough
- pipe
- Oslo type (forced convection).

2.5 describe the construction, operation and application of evaporative crystallisers

- Oslo type
- vacuum pan
- short tube.

2.6 describe the construction, operation and application of evaporative/cooling crystallisers

- Oslo type
- tank type.

2.7 explain the principle of multiple effect crystallisation and the advantages of different feeding arrangements

- parallel feed
- mixed feed.

2.8 explain the use of vacuum in crystallisation operations.

2.9 state problems affecting the efficiency of evaporative crystallisers

- corrosion and erosion
- scaling and fouling
- foaming, splashing and entrainment
- venting
- viscosity changes
- elevation of boiling point.

2.10 describe the construction, operation and application of heat recovery systems in evaporative crystallisers

- condensate flash system

- feed preheat
- flash evaporation
- vapour recompression.

2.11 describe factors that affect choice of heat recovery systems.

2.12 identify process variables monitored and controlled during crystalliser operations

- feed rate
- feed temperature
- concentration of magma
- temperature of heating or cooling
- vacuum
- level.

2.13 explain the importance of crystallisation monitoring and the procedures for carrying it out.

2.14 state causes and corrective actions to be taken for process faults

- solution too dilute
- solution too concentrated
- loss of vacuum
- premature crystallisation
- excessive vapour entrainment
- temperature/pressure variation
- instrument failure
- blockages
- poor venting.

Learning outcome	**The learner will:**
3. Know the function of essential ancillary equipment required by crystallisation plant	
Assessment criteria	

The learner can:

3.1 state types of pump used on crystallisers

- centrifugal
- axial flow
- vacuum.

3.2 select pumps for duties

3.3 describe applications of valves used on crystallisers

- air operated globe and diaphragm
- pressure relief and pressure reducing valve
- steam traps.

3.4 describe the construction, operation and application of vapour condensers

- surface type
- contact type
- jet type
- barometric type.

3.5 describe the construction, operation and applications of entrainment separators used on crystallisation operations.

3.6 describe the construction, operation and applications of agitators used in crystallisers.

3.7 describe the construction, operation and applications of salt removal systems.

Learning outcome	The learner will:
4. Know the safety hazards associated with crystallisation processes and the precautions necessary to minimise them	
Assessment criteria	
The learner can: 4.1 describe precautions necessary to minimise hazards associated with crystallisation equipment and operations • hot surfaces • implosions of vacuum systems • explosions of pressure systems • foaming and splashing • leaks and blockages • thermal decomposition.	

Unit 309 Mixing and blending of solids and fluids

Unit reference:	**M/503/0467**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture.
Assessment requirements	Centre Devised
Aim	This unit provides the essential knowledge for an understanding of the problems associated with the mixing and blending of solids and fluids and the techniques used by industry to overcome them.

Learning outcome	**The learner will:**
1. Understand the factors that affect the mixing and blending of solids and fluids and explain how they influence the choice of equipment and technique	
Assessment criteria	
The learner can: 1.1 explain factors which affect the choice of methods used for transferring solids • particle size and size range • density • moisture content, moist, wet, dry • tendency to flow freely • abrasive nature of solid • whether toxic, flammable or explosive • direction to be moved - vertical or horizontal. 1.2 explain the principles of methods for transferring solids • mechanical • pneumatic • hydraulic. 1.3 explain the principles of equipment used for separating solid particles from gas streams • centrfugal • filtration	

- scrubbing
- electrostatic precipitation.

1.4 identify differences between mixing, blending and contacting.

1.5 explain factors which affect the mixing of solids with solids

- particle size
- relative quantities
- relative densities
- shape of particles
- cohesive nature of particles (stickiness)
- aggregation.

1.6 explain factors which affect the mixing of solids with liquids

- particle size
- relative density
- relative quantities
- surface tension
- wettability

1.7 explain factors which affect the efficient mixing of liquids with other liquids

- temperature
- viscosity
- relative density
- relative quantities
- interfacial tension
- design and size of mixing vessel
- size and speed of agitator
- use of baffles.

1.8 explain the importance of turbulence in solid/liquid and liquid/liquid mixing.

Learning outcome	**The learner will:**
2. Understand the construction, operation and application of equipment used in the mixing and blending of solids and fluids	
Assessment criteria	

The learner can:

2.1 describe the construction, operation and application of mechanical methods of transferring solids

- screw conveyors
- belt conveyors
- vibrating conveyors
- bucket elevators.

2.2 describe the construction, operation and applications of pneumatic conveying systems

- pressure pneumatic conveying
- vacuum pneumatic conveying
- fluidised bed conveying.

2.3 describe the construction, operation and applications of hydraulic conveying systems.

2.4 describe the construction, operation and applications of equipment used for separating solid particles from gas streams

- cyclones
- bag filters

- scrubbers
- electrostatic precipitation.

2.5 describe the construction, operation and applications of equipment used for mixing insoluble solids/liquid and solid/solid systems

- ribbon mixers
- Z-blade mixers and kneaders
- planetary mixers
- roll mills
- ball mills
- edge runners
- pug mills
- dry solid blenders
- vertical helical screw mixers.

2.6 describe the construction, operation and applications of equipment used for batch mixing of liquids with liquids

- external circulation from tank
- propellers in tank
- paddles in tank (anchor, gate, finger)
- turbine in tank (shrouded, semi-shrouded).

2.7 describe the flow patterns produced in tanks using propellers, paddles and turbine mixers.

2.8 explain the design and function of baffles and draft tubes used in tank mixers

- production of turbulence
- vortex elimination.

2.9 describe the construction, operation and application of in-line mixing and contacting equipment

- globe valves
- centrifugal pumps
- perforated plates
- propellers in pipes
- injectors.

2.10 select mixers for duties.

2.11 explain factors affecting the choice of methods of mixing

- power consumption
- ease and quickness of discharge
- nature of materials to be mixed
- ease of cleaning.

2.12 describe general procedures for the start-up and shut-down of pumps used in mixing and blending operations.

2.13 describe methods used to ensure safe, efficient transfer of fluids associated with mixing and blender operations

- bursting discs
- steam tracing
- jacketing.

2.14 explain why mixing equipment should be kept clean (internally and externally)

2.15 describe methods for cleaning equipment

- use of solvents
- general housekeeping
- mechanical methods
- pigging and high pressure jetting for pipes.

Learning outcome	The learner will:
3. Know the hazards associated with mixing and blending equipment and the precautions which will minimise them	
Assessment criteria	
The learner can: 3.1 describe precautions necessary to minimise hazards associated with the transfer of solids • static electricity • flammable and explosive dust • toxic dust • erosion. 3.2 describe precautions necessary to minimise hazards associated with mixing and blending equipment and operations • flammable and explosive dust, liquids and vapours • electrostatic charge development • physical injury from mechanical equipment • toxic dust, liquids and vapours.	

Unit 310 Water for process industries

Unit reference:	**T/503/0468**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Centre Devised
Aim	This unit provides the essential knowledge required for an understanding of the sources, uses and quality requirements of water for use within process industries, including the environmental factors associated with its treatment and use.

Learning outcome	**The learner will:**
1. Understand the chemical and biological considerations associated with water technology	
Assessment criteria	
The learner can: 1.1 explain the chemistry of water technology • atoms, molecules and ions • chemical system of masses • molecular chemistry of water • solutions, acids and alkalis • solutions and suspensions • disassociation and pH • electrolytes • measurement of concentration • molar system and equivalents • calcium carbonate system • conductivity • hardness (temporary and permanent). 1.2 describe biological considerations in water technology • bacteriological action	

- disinfection
- effect of organic matter on the oxygen content and consequences for marine life
- biological oxygen demand
- chemical oxygen demand
- total carbon content
- effect of detergents
- particulates in water.

1.3 explain factors that cause and control scaling and corrosion by water

- corrosive properties of water on different metals
- passivation
- electrical factors in corrosion
- effect of pH and saturation index
- scale formation and prevention.

Learning outcome	**The learner will:**
2. Know typical impurities found in water and treatments required to render water fit for its intended purpose	
Assessment criteria	

The learner can:

2.1 describe the management of systems used to raise steam

- main features of a steam/water system in a typical factory
- effects and prevention of impurities in steam/water systems, ie dissolved oxygen, CO2, scale, pH, de-aerating
- calculations used in boiler water management.

2.2 describe factors and treatments that influence the use of water for domestic and cooling purposes

- once-through & closed circuit cooling
- biological growth
- scale inhibition
- pH adjustment
- corrosion control
- blowdown from cooling water systems
- ion exchange
- water softening
- deionization
- organic fouling.

2.3 describe the use of membrane processes for water treatment

- description of membranes
- electrodialysis
- osmosis
- reverse osmosis
- types of reverse osmosis equipment including: tubular plate and frame, spirally wound, hollow fine fibres.

Learning outcome	The learner will:
3. Know the environmental issues related to the use of water in industry	
Assessment criteria	
The learner can: 3.1 describe environmental issues affecting the use of water in industry • disposal of waste water streams • restrictions on discharge – consent levels • economical factors involved in re-cycling waste water streams.	

Unit 311 Principles of process control and fault diagnosis

Unit reference:	**A/503/0469**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Short Answer
Aim	Modern process plants and manufacturing processes have an increasing amount of process control equipment and systems. This unit will allow technicians to improve their knowledge of process control systems and their constituent components. The unit will also enable candidates to develop a logical approach to fault finding.

Learning outcome	**The learner will:**
1. Understand the fundamentals of a control system	
Assessment criteria	
The learner can: 1.1 describe types of automatic control systems • Open loop control • closed loop control. 1.2 identify modes of process control • two step • proportional • integral • derivative. 1.3 describe the essential features of two-step control • position of actuator • error • set point • measured variable.	

1.4 state the effects of process lag
1.5 state applications of two-step control
- thermostat
- level control within set limits.

1.6 state limitations of two step control
- inability to maintain desired value
- overlap.

1.7 describe essential features of proportional control
- manual resetting of offset
- output made proportional to deviation
- relationship between output and deviation
- actuator setting proportional to the error over range of values.

1.8 identify differences between proportional band and gain.
1.9 state applications of proportional control
- systems where offset is acceptable
- level loops.

1.10 state limitations of proportional control.
1.11 calculate output compared to deviation for proportional settings.
1.12 describe essential features of integral control systems
- signal size related to error
- restores the control loop to set point.

1.13 state applications of proportional plus integral control
- pressure control
- level control
- flow control.

1.14 describe essential features of derivative control systems
- long time lags
- large distance velocity lags.

1.15 state the need for derivative action
- when there are large lags in the system.

1.16 describe benefits of the addition of derivative action to a control process
- temperature control
- large vessel pressure control
- flow control
- loops with few lags.

1.17 describe what is meant by three-term controllers.
1.18 describe the use of three-term controllers

Learning outcome	**The learner will:**
2. Know the various components that constitute a control system	
Assessment criteria	

The learner can:
2.1 identify types of control valves
- butterfly valve
- plug valve
- needle valve
- diaphragm valve
- solenoid valve

- pressure regulator.

2.2 outline the principles of operation of types of valves

2.3 state types of valve plugs

- semi-throttle
- linear
- equal percentage

2.4 describe applications of valve plugs

- two step control
- where fairly constant conditions occur
- where pressure drop is uncertain

2.5 state functions of valve positioners

- to reduce effective lags
- to overcome valve hysteresis
- split range.

2.6 describe factors which affect the location of detecting elements within control systems

- transmission problems
- corrosion.

Learning outcome	**The learner will:**
3. Know the different types of computer control system	
Assessment criteria	

The learner can:

3.1 describe advantages of Direct Digital control (DDC) in relation to conventional panel based control systems

- control panel not needed
- discrete controllers not required for each loop
- main computer controls all of the plant.

3.2 describe disadvantages of DDC

- computer fails, whole plant fails
- computer overloaded makes system slow to react.

3.3 describe features of Distributed Control systems (DCS)

- computers control various parts of the plant
- no master computer
- if one computer fails only part of the plant affected
- all computers are in constant communication
- most systems have redundancy.

3.4 describe differences between DDC and DCS systems.

3.5 describe how the use of DCS improves system reliability.

3.6 describe equipment needed for operators to communicate with DCS

- VDU
- keyboard
- printer
- disk drives.

3.7 describe Supervisory Control And Data Acquisition (SCADA) systems.

Learning outcome	The learner will:
4. Know logical approaches to fault finding	
Assessment criteria	
The learner can: 4.1 identify differences between faults and the symptoms produced by faults • fault produces a symptom • simple examples. 4.2 describe methods and techniques of locating faults • collect information/data • analyse information/data • use fault location techniques:-random search, half split, progressive search (start to finish or visa versa). 4.3 describe steps taken to diagnose the cause of faults 4.4 classify causes of the failure • wear • misuse or inherent weakness in design, construction or installation 4.5 state remedial actions to be taken when faults have been diagnosed • obtain a permit to work • repair fault • test system • sign off permit • hand over to production	

Unit 312 Principles of compressors and compression technology

Unit reference:	**Y/503/0575**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Short Answer
Aim	This unit provides the essential knowledge for an understanding of the basic principles of compression technology together with the construction and operation of compressors used in chemical and process industries.

Learning outcome	**The learner will:**
1. Understand the use of compressed gases in process industries and the basic principles of gas compression	
Assessment criteria	
The learner can: 1.1 explain uses of compressors in industrial processes • liquefaction of gases • refrigeration processes • separation of gases by low temperature distillation or solvent extraction • providing a driving force for transfer/distribution of gases • production of compressed air for industrial purposes; o conveying solids o cleaning equipment o furnace firing/oil atomisation o gas turbine engines. 1.2 explain the gas laws and combined gas equation. 1.3 perform calculations involving changes in temperature, pressure and volume of fixed masses of gases.	

1.4 explain the concepts of isothermal and adiabatic expansion.
1.5 identify differences between heat capacities of gases
- constant volume cV
- constant pressure cp

1.6 explain why gases heat up/cool down under adiabatic conditions of compression/expansion.
1.7 explain the Joule-Thompson effect.
1.8 explain the term compression ratio.
1.9 explain factors affecting the heat of compression
- nature of gas
- temperature
- ratio of compression.

1.10 explain the principles of two stage compression using intercoolers.
1.11 explain the terms capacity and rate as applied to compressors.
1.12 explain the need to dry compressed air before permitting expansion for process use

Learning outcome	**The learner will:**
2. Understand the construction, operation and control of centrifugal and positive displacement compressors	
Assessment criteria	

The learner can:
2.1 describe the construction and operating principles of centrifugal compressors.
2.2 describe functions of basic components of centrifugal compressor systems
- impeller – open and closed types
- shaft seals
- bearings
- balancing drums
- oil circulation systems.

2.3 describe the construction and functions of volute diffusers.
2.4 state functions of safety devices used to protect centrifugal compressors
- overload cut-outs
- thermostats
- governors
- vents and bypasses.

2.5 describe the purposes of performance curves for centrifugal compressors.
2.6 explain effects of external system demands on compressor operations.
2.7 describe the construction and operating principles of rotary compressors
- rotary lobe compressors/blowers
- rotary vane
- sliding vane
- screw.

2.8 describe the construction and operating principles of reciprocating compressors

- single acting
- double acting.

2.9 describe functions of components of reciprocating compressors
- inlet and outlet valves
- cylinder liners
- piston seals
- lubrication systems
- piston construction and piston rings.

2.10 explain the meaning of the term 'volumetric efficiency' as applied to positive displacement compressors.

2.11 describe methods used to control capacities or rates of flow through reciprocating compressors
- throttling
- clearance space control
- unloading
- speed control.

2.12 construct p-V diagrams in relation to the performance of reciprocating compressors-

2.13 interpret p-V diagrams in relation to the performance of reciprocating compressors.

2.14 describe the construction and operating principles of multistage compressor systems using intercooling.

2.15 explain the instrumentation and control requirements of compressor systems
- temperature measurement
- pressure measurement
- flow measurement
- speed indication
- vibration monitoring.

Learning outcome	The learner will:
3. Know the hazards associated with compressor operation and the precautions necessary to minimise them	
Assessment criteria	
The learner can: 3.1 describe the hazards of the production and distribution of compressed gases • high pressure gases • static electricity • hot surfaces • noise • vibration • start-up and shutdown. 3.2 describe the construction, operation and function of essential safety features in compressor systems • safety valves (pressure relief valves) • governors and overspeed trips • oil pressure controls • water temperature controls. 3.3 describe operational procedures for compressors • start-up procedure; o check that it is safe to use the compressor o check the setting of block and vent valves o freedom of liquids/solids in suction line o oil system check o alarm/cut-out system check o start prime mover and warm up o gradually bring on load • steady running – steady state checks • shutdown procedure; o unloading the compressor o cool down o shutdown prime mover	

Unit 313 Drying in process industries

Unit reference:	**D/503/0576**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture.
Assessment requirements	Centre Devised
Aim	This unit provides the essential knowledge required for an understanding of the basic principles, techniques and technology of drying operations carried out in process industries to produce pure, dry, saleable products.

Learning outcome	**The learner will:**
1. Understand the principles and mechanism of drying and the reasons for this operation	
Assessment criteria	
The learner can: 1.1 explain the meaning of terms used in drying technology • humidity • percentage humidity • percentage relative humidity • dew point • moisture content • equilibrium moisture content • critical moisture content • constant rate period • falling rate period. 1.2 explain factors which affect rates of drying • humidity • thermal conductivity of material • rate of heat transfer • latent heat of vaporisation of solvent • material • vapour pressure of solvent	

- temperature and velocity of drying gases
- pressure/vacuum above solid
    - properties of solid
    - moisture content
    - angle of repose
    - bulk density
    - particle size and shape
- feed rate of material.

1.3 construct simple weight-loss/time graphs

1.4 interpret simple weight-loss/time graphs.

1.5 explain how weight-loss/time graphs can be used to achieve optimum operating conditions.

1.6 explain commercial reasons for drying

- easier storage and handling
- produce materials suitable for sale.

1.7 identify differences between the operations of drying and calcining

- drying – low temperature operation to remove solvent (water) from product
- calcining – high temperature process to produce new products.

Learning outcome	**The learner will:**
2. Understand the construction, operation, application and control of drying equipment	
Assessment criteria	

The learner can:

2.1 describe the construction, operation and application of equipment used for drying solids with low water content

- rotary driers:
    - co-current operation
    - counter-current operation
- pneumatic and fluidised bed
- tray and tunnel.

2.2 describe the construction, operation and application of equipment used for drying materials with high water content

- spray driers
- drum driers.

2.3 describe methods of slurry pre-treatment for spray and drum drier systems.

2.4 explain principles of vacuum and freeze drying.

2.5 describe the construction, operation and application of vacuum and freeze driers.

2.6 explain factors affecting the choice of drier systems

- nature of product
- solvent content of feed
- operational costs
- recovery of solvent (non-aqueous).

2.7 justify the choice of drier systems

2.8 explain process variables monitored within drying systems

- inlet and exhaust air temperatures

- product temperature
- air velocity
- exhaust air humidity
- product moisture content
- cycle time
- air pressure
- drier surface temperature
- depth of drying bed.

2.9 describe control loops for control variables

- temperature
- humidity
- air flow.

2.10 state procedures for taking representative samples of wet feed and dried product.

2.11 describe methods of testing samples

- moisture content
- particle size.

Learning outcome	**The learner will:**
3. Understand the function of essential ancillary equipment required during drying operations	
Assessment criteria	

The learner can:

3.1 describe equipment used for transferring materials to and from driers

- mechanical methods
  - skips
  - hoists
  - bucket elevators
  - flat and troughed belt conveyors
  - screw conveyors
  - vibratory conveyors
  - zipper conveyors
- pneumatic methods
  - pressure and vacuum, batch and continuous
  - fluidised systems
  - blow egg systems.

3.2 explain factors which affect choices of transportation methods used in drying operations

- nature of solid
  - powder
  - granular
  - flakes
  - pellets
  - crystals
- properties of solid
  - moisture content
  - bulk density
  - angle of repose

- abrasive nature
- flammability
- toxicity
- distance/height to be moved.

3.3 explain methods of removing solid particles from gas streams

- scrubbers
- cyclones
- electrostatic precipitators
- bag filters
- settling chambers.

3.4 explain factors which affect choices of methods used to remove solid particles from gas streams in drying operations

- particle size
- particle size range
- toxicity
- flammability

Learning outcome	The learner will:
4. Know the problems and safety hazards associated with drying operations and the precautions necessary to minimise them	

Assessment criteria

The learner can:

4.1 describe causes and effects of drying problems

- equipment problems
  - caking
  - poor air distribution and/or venting
  - poor fluidisation
  - accumulation of powder in equipment
  - reliability of sensing devices
  - vibration
  - dust
  - heat losses
- product problems
  - wet product at end of cycle
  - excess fines produced
  - variable moisture content in product
  - thermal decomposition of product
  - contamination.

4.2 describe precautions necessary to minimise hazards associated with drying operations

- dust hazards
  - toxicity
  - explosive mixtures
  - static electricity
  - compressed air hazards (pressure and pneumatic)
  - spontaneous ignition
  - hot surfaces
  - noise
  - solvents (other than water).

Unit 314 Principles of separation of insoluble solids from liquids

Unit reference:	**H/503/0577**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Centre Devised
Aim	This unit provides the essential knowledge for an understanding of the basic principles and techniques behind the separation of insoluble solids from liquids. It also contains essential knowledge covering the construction, operation, control and application of the equipment used.

Learning outcome	**The learner will:**
1. Understand the principles, techniques and methods used to separate insoluble solids from liquids	
Assessment criteria	
The learner can: 1.1 explain techniques used for separating insoluble solids from liquids • flocculation and precipitation • sedimentation • filtration o under gravity o using pressure o under vacuum • centrifugation. 1.2 describe factors that affect the rates of separation of insoluble solids from liquids • shape and size of solid particles • liquid properties o temperature	

- viscosity
- density

- type and characteristics of filter media
- use of filter aid
- type of applied force – gravity, pressure/vacuum, centrifugal.

1.3 describe differences between batch and continuous separation processes

- production rate
- running costs
- equipment costs
- feed characteristics/composition
- product requirements/specifications

Learning outcome	The learner will:
2. Understand the construction, operation, control and application of equipment used in the separation of insoluble solids from liquids	
Assessment criteria	

The learner can:

2.1 identify differences between the processes of flocculation and precipitation.

2.2 explain the purposes of sedimentation

- to clarify liquids
- to concentrate solids
- pretreatment prior to filtration.

2.3 explain factors affecting the rates of sedimentation using Stokes' law

2.4 explain effects of temperature changes on the rate of sedimentation

2.5 explain the use of flocculating agents in sedimentation.

2.6 describe the construction, operation, control and application of sedimentation equipment

- simple batch settling tanks
- settling cones
- Dorr thickeners
- clarifiers
- multi-stage units.

2.7 describe the construction, operation, control and application of filtration equipment

- sand / porous solid filters
- filter presses; plate and frame, chamber
- leaf filters; Moore, Kelly, Sweetland
- rotary filters
- cartridge filters
- edge filters.

2.8 explain the term filter media

2.9 identify filter media

- cloth
- man-made fibre
- metal
- ceramic

- plastic
- glass (sintered)/ glass fibre.

2.10 explain factors affecting choices of filter media
- nature of mother liquid
- nature of precipitate/particle
- cost.

2.11 explain the desirable properties of filter media
- chemical or solvent resistant
- resistance to swelling
- susceptibility to blinding.

2.12 explain the need for filter aids

2.13 list filter aids
- kieselguhr
- activated charcoal
- cellulose fibres.

2.14 explain methods of improving filtration and filtration rates
- pre-treatment of feed
  - preciptation condition
  - flocculation
  - sedimentation
- choice of filter media
- use of filter aids
- increasing type of applied force.

2.15 describe the process of centrifugation.

2.16 describe the construction, operation, control and application of types of centrifuge
- batch
  - overdriven
  - underdriven
- semi-continuous
  - horizontal.

2.17 explain factors affecting the performance of centrifuges
- speed of rotation
- viscosity of liquid
- size and density of solid particles
- type of filter media
- use of filter aids.

2.18 explain factors affecting the choice of separation techniques
- physical characteristics of solids and liquids to be separated
- volume to be handled
- nature of product
- degree of separation
- rate of separation

Learning outcome	The learner will:
3. Know the safety hazards associated with the separation of insoluble solids from liquids and the precautions necessary to minimise them	
Assessment criteria	
The learner can: 3.1 describe precautions necessary to minimise hazards associated with operations involving separation of insoluble solids from liquids by filtration • high pressure • vacuum • hot liquids • toxic slurries and vapours • acid or alkali slurries • mechanical hazards – moving machinery parts • static electricity. 3.2 describe precautions necessary to minimise hazards associated with the operation of centrifuges • mechanical hazards • uneven loading • electrical hazards • overloading • critical speeds • noise.	

Unit 315 Size reduction in process industries

Unit reference:	**T/503/0597**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture.
Assessment requirements	Centre Devised
Aim	This unit provides the essential knowledge for an understanding of the principles and processes of size reduction as carried out in process industries.

Learning outcome	**The learner will:**
1. Understand the principles of size reduction and the reasons for carrying out this operation in process industries	
Assessment criteria	
The learner can: 1.1 explain purposes of size reduction • to make materials easier to handle, store and transport • to provide a larger surface area for chemical reaction or improve solubility • to produce the desired product particle size for a particular use • to allow separation of unwanted material by mechanical or magnetic means. 1.2 describe the choices of size reduction equipment in terms of feed material properties • hardness • abrasiveness • homogeneity • melting point • toxicity • flammability • corrosiveness. 1.3 explain the Mohr scale of hardness. 1.4 explain the forces required to achieve size reduction	

- shear
- compression
- impact
- attrition.

1.5 explain the importance of Kick's law and Rittinger's law in size reduction operations.

Learning outcome	The learner will:
2. Understand the construction, operation, application and control of size reduction equipment	
Assessment criteria	

The learner can:

2.1 explain categories of size reduction processes and equipment

- primary (crushing)
- intermediate
- fine size (grinding)
- ultrafine.

2.2 describe the construction, operating principles and application of primary crushers

- jaw crushers
- gyratory crushers
- roll crushers
- cone crushers.

2.3 explain factors affecting choices of primary crushers

- size range of raw material
- required size range of product
- hardness of feed material
- moisture content of feed material
- product throughput
- energy costs
- initial costs
- maintenance.

2.4 identify sizes and size ranges of products from primary crushers.

2.5 identify size reduction forces associated with primary crushers

2.6 describe the construction, principles of operation and application of intermediate size reduction equipment

- single roll crushers
- double roll crushers
- edge and end runner mills
- impact mills (hammer and stamp mills)
- squirrel cage disintegrator/shredder.

2.7 explain factors affecting the choice of intermediate crushers

- size range of feed material and product
- hardness and moisture content of feed material
- product throughput
- initial and energy costs
- maintenance.

2.8 identify sizes and size ranges of products from intermediate size reduction equipment.

2.9 describe the construction, operating principles and application of

fine size reduction equipment (grinders)

- single and multiple roll mills
- Raymond mills
- Griffin mills
- rod and tube mills
- ball and pebble mills
- vibration mills
- hammer mills with classification.

2.10 explain factors affecting choices of fine size reduction equipment

- nature of feed material
- feed particle size
- energy costs.

2.11 identify size and size ranges of products from fine size reduction equipment.

2.12 describe the construction, operating principles and application of ultrafine size reduction equipment (ultrafine grinders)

- fluid energy mills
- colloid mills.

2.13 explain factors affecting choices of ultrafine size reduction equipment

- nature of feed material
- energy costs.

2.14 identify size and size ranges of product from ultrafine equipment.

2.15 explain advantages and disadvantages of wet grinding processes

- advantages
  - lower power consumption
  - plant capacity increased
  - solids easier to handle
  - dust formation eliminated
  - amount of fines reduced
- disadvantages
  - wear on grinding medium greater
  - wet product may need to be dried.

2.16 identify differences between open and closed size reduction processes in terms of sequence of operations

- feed to crusher/grinder
- particle size classifier
  - product path
  - oversize return
  - undersize (fines)
- feed to next stage.

2.17 explain complete size reduction procedures

- crushing
- size classifier
- grinding
- size classifier
- product/oversize/undersize.

2.18 explain types of control systems for size reduction operations

- manual
- automatic.

Learning outcome	The learner will:
3. Understand the problems, process faults and safety hazards associated with size reduction operations and the precautions necessary to minimise them	
Assessment criteria	
The learner can: 3.1 explain causes of process faults • too little output flow from crusher/grinder – blockage • too much oversize – wear of surfaces • overloading of drive motor o too much feed o clearance between surfaces too small. 3.2 describe precautions necessary to minimise hazards associated with size reduction equipment • mechanical hazards – moving parts • explosive dusts • pyrophoric materials • toxicity • static electricity.	

Unit 316 Gas Treatment in process industries

Unit reference:	**J/503/0670**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Centre Devised
Aim	This unit provides the essential knowledge for an understanding of the basic principles behind gas treatment in process industries, together with the construction, operation and application of the equipment used.

Learning outcome	**The learner will:**
1. Understand the principles behind gas treatment together with the reasons for carrying out this operation in process industries	
Assessment criteria	
The learner can: 1.1 describe different gas based systems associated with industrial processes • gas/gas and gas/vapour systems • gas/liquid suspensions • gas/solid suspensions. 1.2 describe the importance of gas treatment in process industries • reduction of atmospheric pollution • reduction of hazards from dust and toxic gases • separation and recovery processes. 1.3 describe common gas treatment operations carried out in process industries • separation of product gases from effluent gas streams and chemical reactions • removal of toxic and obnoxious gases from effluent gas streams • removal of liquid droplets and mists from effluent gas streams	

- evaporation
- liquid/liquid contacting

- removal of solid particles/dust from gas streams
  - size reduction operations
  - aggregation operations
  - particle size classification operations
  - drying operations.

1.4 explain the importance of particle size and particle size range in gas cleaning operations.

1.5 explain the principles of absorption as they apply to recovery of products from gas streams.

1.6 explain the principles of adsorption as they apply to gas treatment operations

- recovery of valuable minor products
- removal of noxious and toxic gases.

1.7 explain the principles of scrubbing as a gas cleaning method.

1.8 explain the principles of filtration as they apply to gas treatments/cleaning.

1.9 describe the principles behind the operation of cyclones

- gas velocity
- centrifugal force
- gravity.

1.10 explain the principles of electrostatic precipitation of solid (dust) and liquid (mist) particles from gas streams.

Learning outcome	**The learner will:**
2. Understand the construction, operation, control and application of gas treatment systems	
Assessment criteria	

The learner can:

2.1 describe the construction and operation of gas/gas systems using packed absorption towers

- packings and their desirable properties
  - large wetted surface area
  - minimum restriction to flow
  - create turbulence
  - resistance to corrosion and erosion
  - stable at working temperature
- internal fittings and their function
  - demisters
  - liquid distribution plates
  - packing supports.

2.2 describe the construction and operation of gas/gas systems using plate absorption towers

- plate types
  - bubble cap plates
  - weir plates
  - perforated plates
  - Glitsch valve plates.

- internal fittings
    - demisters
    - liquid distribution plates
    - bubble cap base plates.

2.3 explain the importance of essential control systems for absorption towers

- pressure and pressure differential control
- temperature control
- bottom level control.

2.4 describe factors that affect choices of construction material for packed and plate absorption towers

- gas stream temperature
- corrosive nature of gas streams
- flow rates – erosion problems.

2.5 explain special absorber systems required by acid manufacturing plants

- nitric acid production absorbers
- graphite absorbers for hydrochloric acid.

2.6 identify differences between absorption and adsorption.

2.7 describe the construction and operation of adsorption systems for gas treatments

- adsorption media
    - activated wood charcoal
    - coconut charcoal
    - iron oxide
- stripping procedures
    - steaming
    - heat stripping
- product recovery.

2.8 describe control systems for adsorption equipment

- flow rate
- temperature
- pressure.

2.9 describe the construction, operation and control of gas/liquid and gas/solid gas treatment systems

- spray scrubbers
- venturi scrubbers
- oil bath scrubbers
- gas drying systems
    - molecular sieves
    - solid desiccants
    - sulphuric acid scrubbing
- large diameter cyclones
- small diameter cyclones.
- filtration systems
    - demister pads, wire wool pads
    - candle filters: porous solids, polypropylene/wire wool thimbles
    - vane mist eliminators
    - bag filters
    - filter screens

- settling chambers
- electrostatic precipitators.

2.10 explain factors that affect choices of equipment used in gas cleaning operations

- gas/gas systems
  - properties and characteristics of the gas to be extracted
  - gas concentration
  - gas temperature
- gas/liquid and gas/solid systems
  - particle size
  - particle size range
  - degree of separation
  - temperature
  - moisture content.

2.11 select suitable systems for gas treatment duties

Learning outcome	**The learner will:**
3. Know the problems and safety hazards associated with gas treatment operations and the precautions necessary to minimise them	
Assessment criteria	

The learner can:

3.1 describe precautions necessary to minimise hazards associated with gas treatment operations

- low oxygen levels in gas streams and equipment interiors
- use of oxygen alarms, oxygen testing of atmospheres inside equipment
- Entry into Vessels and Permit to Work systems
- vessel cleaning – aqueous and non-aqueous effluents
- dust
  - dust inhalation
  - explosion of organic dusts
  - filter mask use
- cleaning of cyclones and electrostatic precipitators
  - entry into vessels
  - use of harness
  - scraping of internal components
- static electricity.

Unit 317 Principle of process quality

Unit reference:	**M/503/0579**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Centre Devised
Aim	This unit is designed to provide candidates with a sound understanding of Quality Systems in relation to the Processing Industry. In order to comply with product specifications and respond to customers it is important that an individual understands the relevant Quality Standards that apply to their company and to the Industry as a whole.

Learning outcome	**The learner will:**
1. Understand the main factors influencing Quality Assurance in Process Industries	
Assessment criteria	
The learner can: 1.1 explain how quality standards must be controlled throughout processes • raw materials • intermediate products • utilities/services • final products • packaging • packaged products. 1.2 explain the importance of personnel in quality maintenance • operator performance • training • maintaining process environment • communication. 1.3 describe the consequences of failing to meet specified quality standards.	

Learning outcome	The learner will:
2. Know the consequences of not achieving quality standards	
Assessment criteria	
The learner can: 2.1 describe the term quality performance • right first time • quality control • quality Assurance • Total Quality Management (TQM). 2.2 describe the consequences for businesses of not achieving quality first time • low process yields • waste • unproductive plant • unproductive personnel • customer complaints • reprocessing • warehouse space • schedule disruption • upstream/downstream quality problems.	

Learning outcome	The learner will:
3. Understand the importance of quality standards to Process Industries	
Assessment criteria	
The learner can: 3.1 explain the importance of ISO 9001:2000 standards to process industries. 3.2 explain the importance of ISO accreditation as a quality indicator	

Learning outcome	The learner will:
4. Know the differences between on-line and off-line quality control procedures	
Assessment criteria	
The learner can: 4.1 identify differences between on-line and off-line quality control procedures. 4.2 explain advantages and disadvantages of on-line and off-line quality control procedures • response time • instrumentation reliability • availability of information • communication. 4.3 describe on-line quality analysis techniques for solids, liquids and gases.	

Learning outcome	The learner will:
5. Understand how customer feedback can be used to assess quality performance	
Assessment criteria	
The learner can: 5.1 describe the importance of customer feedback. 5.2 describe methods of analysing and assessing customer complaints. 5.3 explain the importance of key factors in analysing and assessing customer complaints • classification of complaint • frequency • time • personnel responsibilities • information interrogation. 5.4 describe the importance of customer interfacing and contact in relation to problems and maintaining acceptable quality data. 5.5 explain the consequences of despatching unsatisfactory products • market share loss • liabilities • customer process risk • health and safety concerns.	

Unit 318 Sampling and laboratory analysis in process industries

Unit reference:	**K/503/0581**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Centre Devised
Aim	This unit provides the essential principles for an understanding of the concepts necessary to carry out sampling and laboratory analysis to maintain quality in the process industries.

Learning outcome	**The learner will:**
1. Understand the principles of representative sampling	
Assessment criteria	
The learner can: 1.1 explain the hierarchy of sampling stages • sampling unit • increment • gross sample • sub-sample • analysis sample. 1.2 describe sampling methods appropriate to solids • from conveyor belts • use of thiefs for particulate matter at rest • use of an auger for compact solids • sub-sampling using coning and quartering • sub-sampling using riffling. 1.3 describe sampling equipment appropriate to liquids • flowing in open systems • flowing within closed systems • stored in closed containers • in open bodies.	

1.4 describe locations for gas sampling
- in narrowly defined areas (eg boreholes and chimney stacks)
- in enclosed areas (eg factory atmospheres)
- in open atmospheres.

1.5 describe gas sampling methods
- isokinetic sampling (pitot tube)
- aspiration into cylinders fitted with stopcocks
- by displacement of liquid
- expansion into an evacuated vessel
- by sampling pump
- passive sampling.

1.6 describe gas sample treatments for isolation of components
- diffusion sampling (into a tube containing adsorbent)
- cyclone sampling (separating different particle sizes)
- filtration.

1.7 explain methods for maintaining the integrity of samples
- correct material for storage container
- exclude air by filling sample container
- correct temperature.

1.8 state causes of loss of sample integrity
- loss of volatile components
- reactions of the components with air
- decomposition in the presence of ultraviolet light
- degradation caused by changes in temperature
- changes due to catalytic activity
- reaction with sample container

1.9 explain reasons for samples not being representative.
- sampling conditions not followed
- storage procedures not followed
- method has inappropriate sampling or storage conditions
- taken from the wrong part of the batch.

Learning outcome	**The learner will:**
2. Understand common methods of analysis	
Assessment criteria	

The learner can:

2.1 describe the principles of pH measurements.

2.2 explain the principles of acid/ base titration.

2.3 describe changes in pH associated with titration of bases with hydrochloric acid
- sodium hydroxide
- sodium carbonate
- sodium hydrogen carbonate
- mixtures of these bases.

2.4 describe the principles involved in measurements of specific gravity.

2.5 describe the principles involved in gas chromatography.

2.6 describe methods of measurement of moisture content of solids
- gravimetric

- moisture meter.

2.7 explain the principles involved in the Karl Fisher method of measuring water content of liquids.

2.8 describe colorimetric analysis.

2.9 describe analysis of trace metals by atomic absorption.

2.10 describe the principles of conductivity measurements

2.11 describe methods of reporting results

- method of Reporting
- hard copy for supervisor to assess
- paper or computer results sheet
- verbal reporting to supervisor/shift foreman plus highlighting in report

Learning outcome	**The learner will:**
3. Understand how to assess risks associated with the use, storage and disposal of laboratory chemicals	
Assessment criteria	

The learner can:

3.1 explain chemical hazards

- flammable
- oxidising agent
- corrosive
- explosive
- harmful
- toxic
- carcinogenic/mutagenic.

3.2 explain options for minimising risks from hazards

- Find an alternative method/chemical
- Appropriate storage
- Choice of location for procedure
- Reduce quantities
- Personal protective equipment.

3.3 explain how risks from chemicals are assessed.

3.4 state methods of storage for chemicals

Chemical	**Storage**
flammable solvent	metal solvent cabinet
Explosive	double container, containing vermiculite
concentrated acids	dedicated cabinet
chemicals which undergo thermal degradation	appropriate grade of refrigerator
general chemicals	vented store cupboard
Gases	in secured cylinders, outside where possible in a locked cage

3.5 describe methods of waste disposal of laboratory chemicals.

3.6 state methods for waste disposal of chemicals

Chemical	Waste Disposal
flammable solvent	non-chlorinated solvent bottle
Chlorinated solvent	chlorinated solvent bottle
low risk aqueous waste	run to waste with plenty of water - drain possibly connected to site effluent treatment plant
solid waste	dedicated drum container
oil residues	drum or drain to drum
hazardous waste	dedicated drum
Gases	vent in a fume cupboard

3.7 describe legislation governing disposal of laboratory waste.
3.8 explain key factors within risk assessments

Learning outcome	The learner will:
4. Understand the principles of quality procedures in the laboratory	
Assessment criteria	

The learner can:

4.1 state the main types of standards to which laboratories operate
- UKAS
- FDA
- GLP.

4.2 explain the importance of calibration.
4.3 explain the importance of standardised materials.
4.4 explain the importance of standardised procedures.
4.5 describe common procedures which ensure traceability
- unique identification of samples
- unique operator computer password for LIMS
- operator stamp where work is done in hard-back books
- time, date, operator details on results sheets (paper or computer)

4.6 describe features of quality control associated with laboratory instrumentation
- calibration records
- compulsory calibration procedures
- maintenance records
- use of standard materials
- use of stored methods
- methods on a LIMS
- automatic highlighting of “out of spec” results.

4.7 explain the importance of control samples.
4.8 explain the importance of control charts.

Unit 319 Special processes in process industries

Unit reference:	**T/503/0583**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Chemical, Pharmaceutical and Petrochemical Manufacture Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Centre Devised
Aim	Individuals will be able to proactively contribute to the effective operation of their business if they have an in depth understanding of the systems and technologies involved. This unit is concerned with the individuals' understanding of their processing business, its' development and commercial importance. The candidates will be able to demonstrate a wider awareness of their process in the global environment, and also understand the influencing factors and constraints affecting their business sector.

Learning outcome	**The learner will:**
1. Know the industry and the processes within which they work	
Assessment criteria	
The learner can: 1.1 give a detailed description of the industrial sector in which the candidate works. 1.2 describe their processing operation within that sector. 1.3 analyse their process within the context of UK, European and Global sector activity. 1.4 state the specific Health and Safety issues associated with the plant/process, and the steps taken to address them. 1.5 state any environmental concerns associated with the process 1.6 describe any associated treatments, disposal or containment methods used to minimise environmental concerns	

Learning outcome	The learner will:
2. Know any specialised techniques and equipment associated with their process	
Assessment criteria	
The learner can: 2.1 explain the chemistry behind their process, including the formation of any by-products or intermediates. 2.2 compare and contrast the chosen process with other companies operating within the same market sector. 2.3 explain any major operational changes/ new equipment which have been introduced to the selected process to improve the quality or efficiency of the operation. 2.4 describe in detail the major competitors within the chosen industrial sector. 2.5 explain how the company maintains market share. 2.6 explain any political/economic/social influences affecting product sales. 2.7 explain the meaning of process integrity and quality. 2.8 explain the importance of ensuring quality of products.	

Learning outcome	The learner will:
3. Know the methods and modes of material transfer into and out of the processing plant	
Assessment criteria	
The learner can: 3.1 summarise the main modes of material transfers to and from an operating site • transport of bulk solids • transport of bulk liquids • transport of pressurised gases • types of container/packaging • road transfer • rail transfer • sea transfer • air transfer. 3.2 describe the factors influencing the choice of material movements to and from the process plant.	

Learning outcome	The learner will:
4. Understand the use of utilities within their company and their influence on the process	
Assessment criteria	
The learner can: 4.1 describe the main methods of generation of the following major utilities • electricity • compressed air • steam. 4.2 state the major sources of water for industry. 4.3 describe the operation of cooling towers. 4.4 state the different types of water 4.5 explain the uses of water in industry.	

Unit 320 Processing metals in process industries

Unit reference:	**M/503/0596**
Level:	3
Credit value:	10
GLH:	It is recommended that **80** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit provides underpinning knowledge relevant to the following NVQs Metal Processing and Allied Operations level 3 Combined Working Practices level 3 and Laboratory and Associated Technical Activities level 3
Assessment requirements	Multiple Choice
Aim	This mandatory unit builds upon unit 2-12 Metals Processing (Level 2) and provides more detailed information about the production of iron, aluminium and copper. It requires a greater understanding of the processes from metal ore to finished product.

Learning outcome	**The learner will:**
1. Know the production processes used to obtain metals from a metal ores	
Assessment criteria	
The learner can: 1.1 state the chemical composition, metal content and country of origin of metals ores used to produce iron, aluminium and copper. 1.2 describe locations of sites for production of iron, aluminium and copper. 1.3 describe main features and processes of iron, aluminium, and copper production units • iron: o blast furnace o direct reduction of iron • aluminium: o Bayer process o electrolytic reduction cell	

- copper:
  - ore preparation
  - matte smelting
  - matte to blister copper
  - fire refining of blister copper.

1.4 describe the main chemical changes that occur in the production of iron, aluminium and copper from their metal ores.

1.5 describe economic and political factors that influence the use of metals and alloys

- current market prices for iron, aluminium and copper ores
- world availability of iron, aluminium and copper ores
- current market prices of iron, aluminium and copper, and their alloys in cast, and worked conditions
- major world metal labour markets

Learning outcome	**The learner will:**
2. Know how metals are refined and the properties of refined metals/alloys	
Assessment criteria	

The learner can:

2.1 describe steps in production processes for manufacturing steel from molten iron.

2.2 describe steps in the production processes for manufacturing steel from scrap.

2.3 compare the mechanical properties of iron and plain carbon steels.

2.4 describe Hoope's three layer molten bath method for the refinement of Aluminium.

2.5 describe how copper is refined by electrolysis processes using an aqueous copper sulphate electrolyte.

2.6 describe the composition and properties of alloy and stainless steels

- engineering alloy steels - effect of nickel, chromium, vanadium
- ferritic stainless steels - effect of carbon and chromium
- austenitic stainless steels - effect of nickel
- tool steels - effect of tungsten, vanadium and molybedenum.

2.7 compare the principles involved in production and refining of alloys based on iron, copper, aluminium, titanium, and zinc.

Learning outcome	**The learner will:**
3. Understand the casting processes for ferrous and non-ferrous metals	
Assessment criteria	

The learner can:

3.1 describe the stages in continuous casting processes for steel.

3.2 describe the stages in continuous casting processes for aluminium and copper.

3.3 explain why continuous casting has replaced the traditional ingot casting route.

3.4 describe emerging casting technologies

- thin slab casting
- strip casting.

3.5 describe the way in which metals solidify to produce crystalline structures

- nucleation and growth
- dendrites and grains
- grain size and shape.

3.6 describe weaknesses in cast metals

- porosity and segregation
- course grain size.

Learning outcome	**The learner will:**
4. Know how primary and secondary rolling mills are used for the initial shaping of metals	
Assessment criteria	
The learner can: 4.1 describe how metals are heated to correct processing temperatures. 4.2 describe how correct hot processing temperatures are established • reference made to an appropriate thermal equilibrium diagram • metal processed over a range of temperatures to determine best practice. 4.3 describe the layout and operation of primary rolling mills. 4.4 describe operations of secondary rolling mills. 4.5 state advantages of hot working metals • lower metal flow stress • lower stresses on rolling mill machinery • structural refinement of cast metal	

Learning outcome	**The learner will:**
5. Understand hot and cold finishing processes and why each is used	
Assessment criteria	
The learner can: 5.1 explain the operation and layout of finishing hot rolling mills for rod, section and sheet. 5.2 describe cold finishing operations for sheet or wire • softening • acid pickling • deformation stresses and lubricants • rolls and supporting rolls • dies. 5.3 describe the merits of hot and cold finishing operations.	

Learning outcome	The learner will:
6. Understand how the quality of a metal is ascertained and the testing techniques used in this process	
Assessment criteria	
The learner can: 6.1 state the fundamental quantities used in mechanical testing and their SI units • mass • force • stress • strain. 6.2 calculate tensile properties of metals • yield, proof and maximum tensile strength • Young's modulus of elasticity • percentage elongation and percentage reduction in area. 6.3 explain why customers may require tensile test data. 6.4 explain why hardness tests are used as quality control checks. 6.5 explain why impact tests may be specified by customers. 6.6 describe factors that determine the severity of defects • size • shape • location with respect to applied loads. 6.7 describe tests used for locating surface and sub-surface defects • surface: o visual o magnetic particle o dye penetrant • sub-surface: o radio graphs o ultrasonic • surface and sub-surface: o eddy currents.	

Unit 321 Iron making and basic oxygen steel making in process industries

Unit reference:	**J/503/0586**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit provides underpinning knowledge relevant to the following NVQs: Metal Processing and Allied Operations level 3 Combined Working Practices level 3 and Laboratory and Associated Technical Activities level 3.
Assessment requirements	Centre Devised
Aim	This unit explains, discusses and describes the production of iron using an Iron Blast Furnace, and the production of steel from a Basic Oxygen Steel making Furnace.

Learning outcome	**The learner will:**
1. Understand the production of metallurgical coke and reducing gases from natural gas	
Assessment criteria	
The learner can: 1.1 compare sources and properties of reducing agents used to produce iron from iron ore. 1.2 compare the production of coke and cracked natural gas as reducing agents for iron ore. 1.3 describe coke making process with the aid of chemical equations. 1.4 describe the standard methods of testing the quality of metallurgical coke • strength • porosity • ash content. 1.5 explain the chemistry of making coke from coal. 1.6 explain the chemistry of making reducing gases from natural gas	

Learning outcome	The learner will:
2. Understand the sourcing and preparation of iron ore	
Assessment criteria	
The learner can: 2.1 describe the main world sources of iron ore 2.2 explain why the UK no longer uses its own deposits 2.3 estimate future trends. 2.4 describe the operations of open cast mining of iron ore. 2.5 describe the processes involved in pre-treatment of iron ore. 2.6 describe the processes of sintering iron ore. 2.7 compare types and grades of iron ore in relation to thermal efficiency and quality of iron produced.	

Learning outcome	The learner will:
3. Understand the operation and developments of The Iron Blast Furnace	
Assessment criteria	
The learner can: 3.1 describe the construction of Iron Blast Furnaces. 3.2 calculate quantities of materials, which enter and leave Iron Blast Furnaces. 3.3 describe the chemical reactions occurring in Iron Blast Furnaces 3.4 explain why there are variations in chemical compositions of Blast Furnace iron. 3.5 describe systems for controlling entry of solids and discharge of gases from the top of Iron Blast Furnaces, 3.6 describe the effects of fuel injection into Iron Blast Furnaces. 3.7 describe the collection and use of blast furnace gases. 3.8 describe the relative merits of blast furnace size. 3.9 describe the relative merits of reducing iron ore with coke or methane. 3.10 analyse developments made to blast furnace processes to improve efficiency. 3.11 predict possible future trends in blast furnace design and operations.	

Learning outcome	The learner will:
4. Understand the operation of a Basic Oxygen Steel making Furnace	
Assessment criteria	
The learner can: 4.1 describe plant layouts and construction of the Basic Oxygen Steel making vessels. 4.2 describe stages of production of steel from iron in Basic Oxygen Steel making processes • charging, • blowing • control and sampling • tapping • slag removal. 4.3 describe the chemical reactions, which take place in Basic Oxygen Steel making processes 4.4 calculations of approximate heat balance. 4.5 describe why the Basic Oxygen Steel making process has very high production rates 4.6 compare Basic Oxygen Steel making processes with Electric Arc Steel making processes 4.7 explain how Basic Oxygen Steel making plants have developed into efficient units. 4.8 discuss possible innovative future developments that might occur in Basic Oxygen Steel making processes.	

Unit 322 Electric arc steel making, refining and casting in process industries

Unit reference:	**R/503/0588**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit provides underpinning knowledge relevant to the following NVQs Metal Processing and Allied Operations level 3 Combined Working Practices level 3 and Laboratory and Associated Technical Activities level 3
Assessment requirements	Centre Devised
Aim	This unit describes the production of steel using the Electric Arc Steel making Furnace. The unit explains the processes of steel making starting with solid scrap, followed by refining in a secondary steel making unit. The unit concludes with an explanation of the casting of molten steel.

Learning outcome	**The learner will:**
1. Understand the operation of an Electric Arc Steel making Furnace and the process of producing steel from scrap	
Assessment criteria	
The learner can: 1.1 describe the construction of modern Electric Arc Furnaces 1.2 outline the process from charging of solid scrap to tapping of molten steel. 1.3 explain the advantages of eccentric bottom tapping • less tilt to tap steel • improved metal/slag separation. 1.4 explain the advantages of water cooled side walls and roofs • long service life • easy replacement. 1.5 describe how carbon electrodes are water cooled 1.6 explain why water cooling of electrodes decreases electrode	

consumption.

1.7 explain how foaming slags are produced during steel making.

1.8 state the advantages of foaming slags over conventional slags

- better thermal insulation of steel
- electrode can be submerged to reduce radiated heat and lower noise
- long arc practice can be used with higher voltage and lower current.

1.9 explain the use of oxygen and oxy-fuel burners in Electric Arc Steel making.

1.10 explain why Electric Arc Furnaces are used primarily for melting and initial stages of refining.

1.11 compare the making of plain carbon, alloy and stainless steel in Electric Arc Furnaces.

1.12 explain how recent developments are influencing the maintenance schedules of Electric Arc Furnaces

- ease of minor repairs during production
- concept of 'everlasting' furnace hearth.

1.13 describe the environmental concerns of Electric Arc Steel making

- fume control
- water recycling
- noise.

Learning outcome	**The learner will:**
2. Understand Secondary and Special Steel making processes	
Assessment criteria	

The learner can:

2.1 describe the layout of secondary steel making plants.

2.2 state the features of secondary steel making plants that improve steel quality

- uniformity of temperature of molten steel
- reduction in gas and inclusion content of steel
- holding station between melting and casting.

2.3 describe changes to molten steel achieved by use of ladle furnaces

- argon stirring to ensure:
  - even temperature profile
  - reduction in harmful gases
- on line chemical analysis and trim to specification.

2.4 describe the operation of vacuum treatment units.

2.5 explain improvements in quality of steel produced by vacuum treatments.

2.6 describe the operation and fundamental principles of stainless steel manufacture by Argon Oxygen Decarburisation (AOD) processes.

2.7 describe the operation of electro slag re-melting units

2.8 explain the improvements in the quality of the steel produced by electro slag re-melting.

Learning outcome	The learner will:
3. Understand the Chemistry of Steel making	
Assessment criteria	

The learner can:

3.1 list chemical reactions in steel making that are exothermic or endothermic
- endothermic reduction of many oxides:
  - iron oxide
  - silica
  - manganese oxide
- exothermic - oxidation of many elements:
  - iron
  - carbon
  - silicon
  - manganese
  - phosphorus.

3.2 explain the chemical term REDOX with respect to chemical reactions that occur in steel making.

3.3 explain how steel making slags are produced,

3.4 describe different chemical and physical properties.

3.5 describe reactions between carbon and oxygen during steel making.

3.6 describe how steel is deoxidised
- silicon
- manganese
- aluminium.

3.7 discuss the chemical principles of preferential oxidation as applied to steel making.

3.8 compare the conditions under which steel is wild/boiling or killed/deoxidised.

3.9 explain how the non-metallic content of steel is reduced by argon purging or vacuum degassing.

3.10 explain howsteel chemical specifications are achieved by alloy additions.

3.11 describe the oxidation of elements in carbon steel
- silicon
- manganese
- phosphorus.

3.12 calculate quantities of oxygen used and temperature rise expected during oxidation processes

3.13 describe the removal of silicon, manganese and carbon as functions of time versus concentration.

3.14 describe, using Le Chatelier's Principle, the mechanism of phosphorus and sulphur removal.

Learning outcome	The learner will:
4. Understand the process of continuous casting	
Assessment criteria	
The learner can: 4.1 explain the operation of continuous casting machines. 4.2 explain why continuous casting processes have replaced ingot casting. 4.3 describe tundish developments in continuous casting • weirs • dams • submerged entry nozzles • refractory linings. 4.4 describe continuous casting mould construction and operation. 4.5 explain what is meant by 'strand solidification' in relation to continuous casting. 4.6 describe the origins of continuous casting defects • panel cracks • oscillation marks • hot metal breakouts • second skin. 4.7 describe special emerging technologies in the continuous casting of metals • horizontal casting • casting sections • thin slab casting • strip casting.	

Unit 323 Primary working in the steel industry

Unit reference:	**Y/503/0589**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit provides underpinning knowledge relevant to the following NVQs Metal Processing and Allied Operations level 3 Combined Working Practices level 3 and Laboratory and Associated Technical Activities level 3.
Assessment requirements	Centre Devised
Aim	This unit at level 3 is an extension of unit 2-15 Primary Working (Level 2). This unit explains in more detail the Primary Working of cast steel and other metals.

Learning outcome	**The learner will:**
1. Understand the process of heating of steel and other metals for Rolling and Forging operations	
Assessment criteria	
The learner can: 1.1 compare types of furnaces used to heat ferrous and non ferrous metals for primary working • pusher and walking beam • batch and continuous • gas fired and electrically heated. 1.2 descibe how carbonaceous fuels burn to produce heat and a reducing furnace atmosphere using chemical equations. 1.3 explain the need for controlled atmospheres when heating various metals for hot working. 1.4 explain how the thermal efficiency of reheating processes can be improved. 1.5 describe how furnace temperatures can be measured and controlled. 1.6 explain how the temperature profile of furnaces can be measured. 1.7 describe the routine maintenance of reheat furnaces.	

Learning outcome	The learner will:
2. Understand the Primary Rolling of steel	
Assessment criteria	
The learner can: 2.1 describe how scale is formed on surfaces of steel and other metals during heating for working. 2.2 explain why scale must be removed before hot working. 2.3 describe a roll pass cross section of angle of bite, draft, roll diameter and rolling force. 2.4 explain the principles of rolling • rolling force • angle of bite • friction. 2.5 explain the development of rolling mills 2.6 explain how rolling schedules are devised.	

Learning outcome	The learner will:
3. Understand hot forging of steel and other metal sections	
Assessment criteria	
The learner can: 3.1 explain how to calculate feedstock size and shape prior to manufacturing forgings. 3.2 compare hot forging processes for ferrous and non-ferrous metals. 3.3 explain the advantages of manufacturing components by hot forging. 3.4 explain how forging productivity can be increased. 3.5 describe the types of forging equipment available. 3.6 describe how developments in forging techniques have improved quality	

Learning outcome	The learner will:
4. Understand the developments in hot plate and strip mills	
Assessment criteria	
The learner can: 4.1 compare the construction and operation of rolling mills for plate and hot strip 4.2 explain how stock thickness is controlled during rolling of hot strip. 4.3 calculate rolling speeds at various positions within continuous hot strip mills. 4.4 explain why coil boxes are used between the roughing and finishing train of hot strip mills. 4.5 explain how hot rolled steel strip is cooled after rolling and before coiling. 4.6 describe the construction and operation of coilers in hot strip mills. 4.7 describe end uses of hot rolled plate and hot rolled strip.	

Unit 324 Finishing working processes

Unit reference:	**L/503/0590**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit provides underpinning knowledge relevant to the following NVQs Metal Processing and Allied Operations level 3 and Combined Working Practices level 3.
Assessment requirements	Centre Devised
Aim	This unit builds upon the Finishing Working Processes (Level 2) unit and describes in more detail the finishing working processes. It includes tube and pipe manufacture, cold strip mills, hot bar and rod mills, and wire and section mills. The unit explains why metals are finished in different ways.

Learning outcome	**The learner will:**
1. Understand welded and seamless pipe manufacture	
Assessment criteria	
The learner can: 1.1 compare production process for welded and seamless pipes. 1.2 describe the main metallurgical effects of welding carbon steels • cast structure in centre of weld • heat affected zone. 1.3 describe the production of copper tubes and pipes. 1.4 explain why high pressure pipe connections are made by machining from solid bars. 1.5 state the relative costs of seamless and welded pipes 1.6 state typical applications of seamless and welded pipes.	

Learning outcome	The learner will:
2. Understand the process variables in the operation of cold strip mills	
Assessment criteria	
The learner can: 2.1 describe types of annealing furnaces used to prepare sheet and strip for cold rolling. 2.2 compare the types of controlled atmospheres used for bright annealing of sheet and strip • cracked ammonia • nitrogen • argon • vacuum. 2.3 describe the construction and operation of cold rolling mills for steel, copper and aluminium. 2.4 explain the process of rolling and the inter-relationship of major variables • flow stress • rolling load • roll diameter • angle of bite • friction. 2.5 explain why small diameter work rolls are used in cold rolling. 2.6 explain how customers specify the finished hardness and size of cold rolled metals . 2.7 explain how producers provide the finished hardness and size of cold rolled metals 2.8 analyse commercial data of the current status of cold rolling plants 2.9 predict possible future developments of cold rolling plants. 2.10 describe products made from strip and wire.	

Learning outcome	The learner will:
3. Understand variables in the operation of hot bar and rod mills	
Assessment criteria	
The learner can: 3.1 explain the inspection and planning of billet feed stocks. 3.2 explain how reheat furnaces are managed to correctly supply material to mills. 3.3 explain how roll pass sequences are determined. 3.4 describe the construction and operation of precision sizing blocks. 3.5 explain the principle of controlled rolling of steel and the importance of finishing temperature . 3.6 describe the operation of coiling rod into down coilers and conveyors. 3.7 predict possible future developments in bar and rod mills using current data.	

Learning outcome	The learner will:
4. Understand the operation of steel and non-ferrous wire and section mills	
Assessment criteria	
The learner can: 4.1 compare rod supplied to wire industries from the UK and overseas. 4.2 compare chemical and mechanical preparations of rod for drawing • acid v. mechanical • environmental legislation. 4.3 compare the operation of wire drawing equipment • single hole • multi hole • straight. 4.4 explain the reasons for wire breaks during drawing • rod defects • overdrawing. 4.5 explain the changes to mechanical properties of steel wire when it is cold drawn. 4.6 explain the processes of inter-stage annealing • annealing curves • types of furnaces • times and temperatures • effect on mechanical properties. 4.7 describe the ways in which drawn wire can be presented to customers • straight lengths • coils • drums • packaging. 4.8 describe the main features in production of shaped wire • die profile • number of passes • ductility and work hardening of metal. 4.9 compare various methods of protecting steel wire from corrosion in service • metal coatings • non-metallic coatings. 4.10 explain how the difficulties in drawing stainless steel wires can be overcome • rapid work hardening • scoring and marking of surface • die lubricants. 4.11 describe the production processes of copper and aluminium wire. 4.12 discuss how electric light filament wire can be made from tungsten. 4.13 describe recent developments in drawing very high tensile steel wire	

Unit 325 High technology processing of metals in process industries

Unit reference:	**R/503/0591**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit provides underpinning knowledge relevant to the following NVQs Metal Processing and Allied Operations level 3 and Combined Working Practices level 3.
Assessment requirements	Centre Devised
Aim	This unit introduces some high technology processes currently being used in the metals industry. These include processes such as strip casting, hot isostatic pressing, laser cutting and welding, powder forming, and advanced vehicle concepts. It would be expected that the learner had some knowledge of more traditional techniques before studying this unit.

Learning outcome	**The learner will:**
1. Know the process of hot isostatic pressing	
Assessment criteria	
The learner can: 1.1 describe the main features of the equipment used for hot isostatic pressing • size and shape of pressure vessel • high pressure system • heating system. 1.2 describe the process cycle for hot isostatic pressing • temperature • pressure • time. 1.3 describe the effects of high pressure and high temperature over a period of time on structures and properties of cast metals.	

1.4 describe how hot isostatic pressing is used to produce components which have superior service lives • cast aluminium alloy turbine wheels for motor car turbo chargers • cast nimonic turbine blades for aircraft engines.

Learning outcome	**The learner will:**
2. Know the process of continuous strip casting	
Assessment criteria	
The learner can: 2.1 describe the main features of strip casting machines. 2.2 compare the process of continuous strip casting with continuous slab casting. 2.3 describe the metallurgical and engineering problems associated with casting of thin strips • bridging during solidification • control over cooling rate • production of a homogeneous structure. 2.4 describe how thin strip casting can be part of continuous production routes for manufacturing items • constructional steel • automotive body sections. 2.5 compare the relative costs and mechanical properties of steel sheets fabricated directly by thin sheet casting and steel sheets fabricated by rolling from continuously cast slabs.	

Learning outcome	**The learner will:**
3. Understand the processes of laser welding, electron beam welding, and friction stir welding	
Assessment criteria	
The learner can: 3.1 describe processes of laser welding, electron beam welding, and friction stir welding. 3.2 explain how welding processes produce superior metallurgical structures in materials being welded. 3.3 explain how welding processes produce better mechanical properties in and near to weld areas than traditional techniques. 3.4 explain why welding techniques produce consistent welds of higher quality. 3.5 explain how welding techniques enable production of sound welds between unweldable material combinations.	

Learning outcome	The learner will:
4. Know the processes of extrusion and powder metallurgy	
Assessment criteria	
The learner can: 4.1 describe processes of extrusion of ferrous and non-ferrous metals and alloys. 4.2 describe steps in production of solid metal shapes from metal powders • select and mix powder • design die shape • green pressing • eject • fuse in controlled atmosphere • inspect and test. 4.3 describe the economic and technical advantages of producing metal shapes using extrusion and powder metallurgy production techniques • zero or very low material waste • zero or little finish machining • production of a shape which is impossible or very difficult to manufacture by traditional techniques. 4.4 describe the types of metal structures produced by extrusion and using metal powder techniques • extrusion produces highly deformed structures • powder techniques produce fused material structure • composites of metals and non metals such as ceramics can be produced by powder metallurgy. 4.5 describe items which can be best or only produced by extrusion and metal powder production methods.	

Learning outcome	The learner will:
5. Understand innovative techniques in the metal's industry	
Assessment criteria	
The learner can: 5.1 explain the development of lightweight motor car body assemblies in steel. 5.2 explain the use of aluminium alloys for motor car body and chassis components. 5.3 explain the coating of metals with ceramic materials to improve temperature resistance. 5.4 explain the replacement of metals with non-metals • water and gas pipes. • fibre glass mouldings on cars and caravans • cutlery in aircraft catering.	

Unit 326 Metallurgy of iron and steel production

Unit reference:	**D/503/0593**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit provides underpinning knowledge relevant to the following NVQs Metal Processing and Allied Operations level 3 Combined Working Practices level 3 and Laboratory and Associated Technical Activities level 3.
Assessment requirements	Centre Devised
Aim	This unit explains and describes many of the metallurgical principles involved in the production and processing of iron and steel.

Learning outcome	**The learner will:**
1. Understand the metallurgical principles involved in the production of steel from iron ore and scrap, including chemical reactions and heat balance	
Assessment criteria	
The learner can: 1.1 explain the chemistry of making coke from coal using simple chemical equations. 1.2 describe equipment and procedures for testing quality of metallurgical coke. 1.3 compare properties of UK and imported iron ores. 1.4 explain technical and economic reasons for pre-treating iron ore before charging to blast furnaces. 1.5 describe the chemical reactions occurring in blast furnaces 1.6 describe developments made to blast furnace processes to improve efficiency • fuel injection • high top pressure • control of charge • size of furnace.	

1.7 describe how sulphur is removed from blast furnace irons prior to charging into the Basic Oxygen Steel (BOS) making furnaces.

1.8 describe chemical reactions in BOS processes.

1.9 calculate heat balances for BOS making processes.

1.10 explain developments which have improved the thermal efficiency of Electric Arc Steel making furnaces

- short melt down times,
- oxygen and fuel injections,
- furnace design
- foaming slags
- high voltage long arc process.

1.11 explain why modern Electric Arc Steel making Furnaces are used only for melting of scrap and initial refining of steels.

1.12 describe the making of steel to specification in secondary steel making units.

1.13 explain how temperature uniformity, reduction in gas and non metallic content, and close control over final analysis are all achieved in secondary steel making units.

1.14 describe improvements in steel quality which are achieved by secondary steel making.

1.15 describe how very high quality steel can be made by re-melting techniques

Learning outcome	**The learner will:**
2. Understand the chemistry of making alloy steels	
Assessment criteria	

The learner can:

2.1 explain oxidation of carbon, silicon, manganese and phosphorus during the oxidation phase of steel making.

2.2 explain the conditions required in order to remove phosphorus and sulphur from steel.

2.3 explain quantitatively how close control is achieved over the final chemical analysis of steel.

2.4 explain why it is desirable to produce homogeneous melts prior to casting and how this influences future processing.

2.5 explain how the addition of small quantities of alloying elements to steel influences future processing.

2.6 state the chemical composition for of ferric, austenitic and duplex stainless steels.

2.7 describe the principles of Argon Oxygen Decarburising processes for the bulk manufacture of stainless steel.

2.8 describe the improvements to steel quality that can be achieved by vacuum treatment and multi stage electro slag re-melting.

2.9 describe uses of steels

- carbon/manganese
- low alloy engineering
- stainless
- special and high alloy.

Learning outcome	The learner will:
3. Understand the process of solidification of a metal alloy	
Assessment criteria	
The learner can: 3.1 label cooling curves for copper/nickel alloys. 3.2 explain the solidification of copper/nickel alloys. 3.3 explain production of cored structures. 3.4 explain how grain sizes can be refined • seeding. • electro-magnetic stirring. 3.5 explain the advantages of compressing metals when only partially solidified.	

Learning outcome	The learner will:
4. Understand the hot working of steel	
Assessment criteria	
The learner can: 4.1 describe the compression of metals between two flat planes using mathematical models. 4.2 explain mathematical models of rolling. 4.3 explain why large diameter work rolls are used for primary rolling of hot steel. 4.4 explain hot working in terms of re-crystallisation temperature. 4.5 estimate hot tensile and compressive data for carbon-manganese constructional steel. 4.6 describe how to minimise defects produced during hot rolling of steel • size • shape • pipe • entrapped flux and segregation • seams • hydrogen cracking • shrinkage cavities • hot tears • stress cracking • walking beams marks • score marks • laps and overfill • cold cracking • rolled in scale • roller marks • guide marks • handling mark. 4.7 explain the principles of controlled rolling of steels 4.8 describe the importance of finishing temperatures.	

Learning outcome	The learner will:
5. Understand the metallurgical principles of cold rolling and cold drawing steel	
Assessment criteria	
The learner can: 5.1 explain why small diameter work rolls are used for cold rolling. 5.2 explain how work hardening rates influence the cold rolling and cold drawing of steel. 5.3 explain why cold working produces close control over surface finish, size and mechanical properties of steel products. 5.4 describe the processes of metal passing through wire drawing die. 5.5 describe reasons why wire breaks during wire drawing.	

Unit 327 Metallurgy of ferrous metals and alloys

Unit reference:	**Y/503/0592**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit provides underpinning knowledge relevant to the following NVQs Metal Processing and Allied Operations level 3 Combined Working Practices level 3 and Laboratory and Associated Technical Activities level 3.
Assessment requirements	Centre Devised
Aim	This unit explains the metallurgical principles of ferrous alloys. It is a broadening unit for those learners who wish to study some of the basic principles of steel structures and properties.

Learning outcome	**The learner will:**
1. Understand the metallurgical structure of ferrous alloys	
Assessment criteria	
The learner can: 1.1 draw atomic structures of hydrogen, carbon and iron • nucleus • atomic number • protons • neutrons • atomic weight • electron shells. 1.2 draw crystalline structures found in ferrous alloys • body centred cubic • face centred cubic. 1.3 describe interstitial and substitutional metal structures found in ferrous alloys • interstitial carbon in steel • substitutional manganese in steel. 1.4 explain how ferrous alloys deform by processes of slip. 1.5 explain why fine grained ferrous alloys are tougher than course	

grained ferrous alloys.

1.6 identify single phased and two phased ferrous microstructures
- pure iron
- low carbon steel.

Learning outcome	The learner will:
2. Understand the process of solidification ferrous alloys	
Assessment criteria	
The learner can: 2.1 explain the changes in atomic structures that occur when ferrous alloys cool from the liquid to solid states. 2.2 draw cooling curves for pure iron and low carbon steels. 2.3 describe the dimensional changes that occur when steel solidifies. 2.4 explain how metal grains can be refined during the solidification of plain carbon steels. 2.5 explain the dimensional changes that occur when low carbon steel cools from hot working temperatures to ambient temperatures. 2.6 describe the iron - iron carbide thermal equilibrium diagram with reference the solidification of steels and cast irons up to 4% carbon.	

Learning outcome	The learner will:
3. Understand the effect of carbon in iron and the application of the iron - iron carbon thermal equilibrium diagram in the steel industry	
Assessment criteria	
The learner can: 3.1 describe the allotropic forms of iron • ferrite - body centred cubic • austenite - face centred cubic. 3.2 describe how the addition of carbon to iron changes the mechanical properties • interstitial hardening • production of a second phase • atomic slip forces increase. 3.3 describe the micro-structural phases present in steels • ferrite • austenite • carbide. 3.4 describe features of the iron - iron carbon diagram up to 1% carbon 3.5 explain the transformation of austenite into ferrite and carbide under equilibrium cooling. 3.6 describe the effect of rapid cooling on the transformation of austenite 3.7 describe the iron carbon diagram in relation to heat treatment cycles. 3.8 describe the process of tempering steel at temperatures below the ferrite to austenite transformation temperatures. 3.9 describe how the iron - iron carbon diagram can be used to determine the upper and lower hot rolling and hot forging temperatures. 3.10 explain the terms decarburisation and carburisation of steels.	

Learning outcome	The learner will:
4. Understand how ferrous metals and alloys are tested and the application of the test data	
Assessment criteria	
The learner can: 4.1 calculate yield stress, proof stress and maximum tensile strength of ferrous alloys 4.2 explain the practical implications of yield stress, proof stress and maximum tensile strength in production and service conditions. 4.3 calculate percentage elongation, percentage reduction in area, and Young's modulus of elasticity of ferrous alloys. 4.4 explain the practical implications of percentage elongation, percentage reduction in area, and Young's modulus of elasticity of ferrous alloys in production and service conditions. 4.5 explain how hardness tests are used as quality control tests. 4.6 explain why impact tests may be specified by customers. 4.7 describe principles of fracture mechanics defect size • defect shape • defect orientation with respect to the applied stress • size of applied stress • material toughness • stress concentration factor. 4.8 describe factors which decide if defects can be tolerated in service 4.9 explain the purpose of bend and nick fracture tests. 4.10 explain why surface defects are more critical than sub surface defects. 4.11 describe visual inspection of finished components. 4.12 explain the limitation of magnetic particle inspection of magnetic ferrous alloys • defect size • depth of defect below surface • orientation of defect in magnetic field. 4.13 describe the linking of eddy current testing to on line production. 4.14 discuss the limitations of ultrasonic inspection • link between probe and metal • orientation of defect with respect to transmitted wave. 4.15 draw the ultrasonic signal from defects in ferrous alloys • hydrogen cracks • weld defects • non-metallic inclusions • large internal cavity. 4.16 explain high profile material failures and how they relate to testing and inspection • railway lines • oil rig legs • motor car component recalls • airframe and aero engine failures.	

Unit 332 Petroleum technology

Unit reference:	**A/5030584**
Level:	3
Credit value:	6
GLH:	It is recommended that **40** hours should be allocated for this unit, although patterns of delivery are likely to vary.
Relationship to NOS:	This unit contributes towards the knowledge and understanding of the following N/SVQs: Level 3 Refinery Field Operations Level 3 Refinery Operations (Control Room).
Assessment requirements	Short Answer
Aim	This unit provides the essential knowledge required for a greater understanding of oil recovery and the production, distribution and processing/refining of crude oil and gas.

Learning outcome	**The learner will:**
1. Understand the key processes involved in enhanced oil recovery (eor)	
Assessment criteria	
The learner can: 1.1 explain the principles of EOR techniques • well water injection • surfactant injection • steam injection • artificial gas lift. 1.2 explain operational and commercial considerations of EOR techniques • cost • environmental impact • effect on geological structures • availability of materials and utilities.	

Learning outcome	The learner will:
2. Understand the detailed construction and operation of the key elements of oil and gas production platforms and distribution systems both on and off shore	
Assessment criteria	
The learner can: 2.1 explain the key operational benefits, constraints and limitations of drilling techniques • vertical • directional • horizontal. 2.2 describe the principles, key features, construction and modes of operation of oil production process units • oil-gas separator • oil-water separator • test separators • desalting unit • flare • gas scrubbers. 2.3 explain the key commercial and operational considerations of operating cross country and sub-sea pipeline systems and shipping • inspection and maintenance procedures, difficulties and costs • generation of revenue • public licence • preventing cross-contamination when multiple materials are transported • geography • climate • environmental impact • corrosion • cleaning • number and position of pumping/booster stations • sampling points and analysis. 2.4 describe the hazards, and precautions necessary to minimise them, associated with production operations • reservoir pressure; blowouts • pollution • flammable hazards • toxicity of materials • difficulty of evacuation and remote areas • helicopter ditching and sea survival techniques • corrosion.	

Learning outcome	The learner will:
3. Know the principles, key features, construction and modes of operation of refinery process units	
Assessment criteria	
The learner can: 3.1 describe in the principles, key features, construction and modes of operation of refinery process units • electrostatic desalting • atmospheric distillation • vacuum distillation • desulphurisation • catalytic conversion/reforming • alkylation • isomerisation • thermal cracker • fluid catalytic cracker • hydrocracker • jetties • tanks and tank farms • kerosene sweetener.	

Appendix 1 Relationships to other qualifications

Literacy, language, numeracy and ICT skills development

This these qualifications can develop skills that can be used in the following qualifications:

- Functional Skills (England) – see **www.cityandguilds.com/functionalskills**
- Essential Skills (Northern Ireland) – see **www.cityandguilds.com/essentialskillsni**
- Essential Skills Wales (from September 2010).

Appendix 2 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the **Centres and Training Providers homepage** on **www.cityandguilds.com**.

Providing City & Guilds qualifications – a guide to centre and qualification approval contains detailed information about the processes which must be followed and requirements which must be met for a centre to achieve 'approved centre' status, or to offer a particular qualification. Specifically, the document includes sections on:

- The centre and qualification approval process and forms
- Assessment, verification and examination roles at the centre
- Registration and certification of candidates
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Frequently asked questions.

Ensuring quality contains updates and good practice exemplars for City & Guilds assessment and policy issues. Specifically, the document contains information on:

- Management systems
- Maintaining records
- Assessment
- Internal verification and quality assurance
- External verification.

Access to Assessment & Qualifications provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for candidates who are eligible for adjustments in assessment.

The **centre homepage** section of the City & Guilds website also contains useful information such on such things as:

- **Walled Garden**
  Find out how to register and certificate candidates on line
- **Events**
  Contains dates and information on the latest Centre events
- **Online assessment**
  Contains information on how to register for GOLA assessments.

Centre Guide – Delivering International Qualifications contains detailed information about the processes which must be followed and

requirements which must be met for a centre to achieve 'approved centre' status, or to offer a particular qualification. Specifically, the document includes sections on:

- The centre and qualification approval process and forms
- Assessment, verification and examination roles at the centre
- Registration and certification of candidates
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Frequently asked questions.

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Useful contacts

UK learners **General qualification information**	**T: +44 (0)844 543 0033** **E: learnersupport@cityandguilds.com**
International learners General qualification information	T: +44 (0)844 543 0033 F: +44 (0)20 7294 2413 E: **intcg@cityandguilds.com**
Centres Exam entries, Certificates, Registrations/enrolment, Invoices, Missing or late exam materials, Nominal roll reports, Results	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: **centresupport@cityandguilds.com**
Single subject qualifications Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 F: +44 (0)20 7294 2404 (BB forms) E: **singlesubjects@cityandguilds.com**
International awards Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: **intops@cityandguilds.com**
Walled Garden Re-issue of password or username, Technical problems, Entries, Results, GOLA, Navigation, User/menu option, Problems	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413 E: **walledgarden@cityandguilds.com**
Employer Employer solutions, Mapping, Accreditation, Development Skills, Consultancy	T: +44 (0)121 503 8993 E: **business_unit@cityandguilds.com**
Publications Logbooks, Centre documents, Forms, Free literature	T: +44 (0)844 543 0000 F: +44 (0)20 7294 2413

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