City & Guilds Level 3 Electrical Power Engineering – Wind Turbine Maintenance (Technical Knowledge) (2339-54)

www.cityandguilds.com
June 2022
Version 2.2

Qualification handbook for centres

600/2700/9

About City & Guilds

City & Guilds is the UK's leading provider of vocational qualifications, offering over 500 awards across a wide range of industries, and progressing from entry level to the highest levels of professional achievement. With over 8500 centres in 100 countries, City & Guilds is recognised by employers worldwide for providing qualifications that offer proof of the skills they need to get the job done.

City & Guilds Group

The City & Guilds Group includes City & Guilds, ILM (the Institute of Leadership & Management, which provides management qualifications, learning materials and membership services), City & Guilds NPTC (which offers land-based qualifications and membership services), City & Guilds HAB (the Hospitality Awarding Body), and City & Guilds Centre for Skills Development. City & Guilds also manages the Engineering Council Examinations on behalf of the Engineering Council.

Equal opportunities

City & Guilds fully supports the principle of equal opportunities and we are committed to satisfying this principle in all our activities and published material. A copy of our equal opportunities policy statement is available on our website.

Copyright

Publications

City & Guilds publications are available from our website or from our Publications Sales department, using the contact details shown below.

Every effort has been made to ensure that the information contained in this publication is true and correct at the time of going to press. However, City & Guilds' products and services are subject to continuous development and improvement and the right is reserved to change products and services from time to time. City & Guilds cannot accept liability for loss or damage arising from the use of information in this publication.

City & Guilds
5-6 Giltspur Street
London
UK
EC1A 9DE
www.cityandguilds.com

City & Guilds Level 3 Diploma in Electrical Power Engineering - Wind Turbine Maintenance (Technical Knowledge) 2339-54

www.cityandguilds.com
June 2022
Version 2.2

Qualification handbook for centres

Qualification title	GLH	TQT	City & Guilds Number	Accreditation number
City & Guilds Level 3 Diploma in Electrical Power Engineering – Wind Turbine Maintenance (Technical Knowledge)	715	780	2339-54	600/2700/9

Version and date	Change detail	Section
2.1 Jun 2013	Amend assessment type	**Various**
2.2 June 2022	GLH and TQT highlighted	**Introduction to the qualifications**

City & Guilds

Skills for a brighter future

www.cityandguilds.com

Contents

City & Guilds
Skills for a brighter future

www.cityandguilds.com

1 Introduction to the qualifications

This document contains the information that centres need to offer the following qualification:

Title and level	GLH	TQT	City & Guilds qualification number	Ofqual accreditation number
City & Guilds Level 3 Diploma in Electrical Power Engineering – Wind Turbine Maintenance (Technical Knowledge)	715	780	2339-54	600/2700/9

Total Qualification Time

Total Qualification Time (TQT) is the number of notional hours which represents an estimate of the total amount of time that could reasonably be expected for a learner to achieve and demonstrate the achievement of the level of attainment necessary for the award of a qualification.

TQT is comprised of the following two elements:

- The number of hours which an awarding organisation has assigned to a qualification for Guided Learning, and
- An estimate of the number of hours a learner will reasonably be likely to spend in preparation, study or any other form of participation in education or training, including assessment, which takes place as directed by - but, unlike Guided Learning, not under the immediate guidance or supervision of - a lecturer, supervisor, tutor or other, appropriate provider of education or training.

Introduction

City & Guilds is proud to introduce for the emerging Renewables sector its first Advanced Apprenticeship, designed specifically for Wind Turbine Service Technicians. This qualification, which delivers the underpinning knowledge component of the apprenticeship, is accredited under the umbrella of City & Guilds' wider power sector related qualifications framework - Electrical Power Engineering (City & Guilds 2339).

This technical qualification - along with its competence-based counterparts (2339 16 & 53) - has been developed through collaborative partnership via the Renewable Energy Apprenticeships Programme (REAP), comprising Renewable UK, major renewable sector employers, the sector skills council and further education colleges.

The knowledge requirements of this technical qualification have been thoroughly scoped through employer workshops, academic review and engineering critique. At its core is a breadth and depth of engineering knowledge, covering electrical, mechanical, hydraulic and control & instrumentation, all of which are fundamental to the development of the skills and knowledge required of a practicing wind turbine engineer. Built around this core engineering are wind energy specific knowledge areas including systems approaches to wind turbines, theory of aerodynamics & meteorology, environmental considerations and wider health & safety responsibilities.

The principle aim of this qualification is to embed in apprentices a deep understanding of the engineering behind the construction and operation of wind turbines. It also aims to instil a wider understanding of the determinants of successful capture of wind and ensuing generation of electricity, including the source of wind, aerodynamics, location of wind turbines / farms as well as the environmental and political context. Additionally, it covers the transfer of energy and its supply and connectivity to the grid.

1.1 Qualification structure

This qualification is made up of seven units of assessment, all of which must be successfully completed to achieve the full qualification.

Accreditation unit reference	City & Guilds unit number	Unit title	Mandatory/ optional for full qualification	Credit value	Level	GLH
M/601/8927	Unit 750	Health and safety in the power industry	Mandatory	4	3	36
M/601/8930	Unit 751	Theory and background of wind turbines and energy	Mandatory	12	3	108
H/503/4340	Unit 752	Mechanical theory and principles of wind turbine technology	Mandatory	14	3	130
M/503/4390	Unit 753	Electrical theory and principles of wind turbine technology	Mandatory	15	3	140
D/601/8941	Unit 754	Control and instrumentation theory and principles of wind turbine technology	Mandatory	7	3	63
A/503/4392	Unit 755	Hydraulic theory and principles of wind turbine technology	Mandatory	14	3	130
T/601/8945	Unit 756	Wind turbine systems technology	Mandatory	12	3	108

1.2 Opportunities for progression

On completion of the level 3 qualifications candidates may have the opportunity of progressing onto supervisory / managerial qualifications.

1.3 Qualification support materials

City & Guilds also provides the following publications and resources specifically for this qualification:

Description	How to access
Assessments	www.cityandguilds.com
Unit handbook	www.cityandguilds.com

2 Centre requirements

This section outlines the approval processes for Centres to offer the Diploma in Electrical Power Engineering – Wind Turbine Maintenance (technical knowledge), including the resources and specific Centre staff requirements.

2.1 Resource requirements

City & Guilds quality assurance includes initial centre approval, scheme approval, the centre's own procedures for monitoring quality and City & Guilds' ongoing monitoring by an External Verifier.

City & Guilds External Verifiers will:

- ensure that internal verifiers are undertaking their duties satisfactorily
- monitor internal quality assurance systems and sampling assessment activities, methods and records
- act as a source of advice and support
- promote best practice
- provide prompt, accurate and constructive feedback to all relevant parties on the operation of centres' assessment systems.

Human resources

In line with the sector skills council Energy & Utility's assessment strategy, all **assessors**, **internal verifiers** and **external verifiers** involved in the delivery of Power sector qualifications (within which the Renewables sector falls) must:

- Demonstrate a high level* of interpersonal and communication skills, comparable with at least the Key Skills and Core Skills (Communication) identified within "Develop productive working relationships with colleagues" (MSC D1)
- Have up-to-date knowledge of current practice and emerging issues within their industry and be aware there may be differences between the four UK countries
- Have a thorough understanding of the assessment units for the qualifications they are assessing or verifying and be able to interpret them and offer advice on assessment-related matters
- Show experience and working knowledge of the assessment and verification processes relating to the context in which they are working
- Demonstrate they have relevant and credible technical and/or industrial experience not more than 5 years old - at a level relevant to their role and the award
- Show they are able to act as an emissary of the awarding body and be able to facilitate consistency across centres
- Have Assessor or Verifier units of competence (A or V units or D units)- or working towards the appropriate TAQA (6317)- or TQFE or TQSE for assessment or verification in Scotland
- Demonstrate a commitment to continuing professional development and to keeping abreast of the changing environment and practices in their industry
- Demonstrate they have relevant and credible technical and/or industrial experience within the industry appropriate to these contexts – overhead, underground or substation.

Centre staff may undertake more than one role, eg tutor and assessor or internal verifier, but must never internally verify their own assessments.

Continuing professional development (CPD)

Centres are expected to support their staff in ensuring that their knowledge remains current of the occupational area and of best practice in delivery, mentoring, training, assessment and verification, and that it takes account of any national or legislative developments.

2.2 Candidate entry requirements

There are no restrictions on entry to the qualifications, although it is expected that candidates will present through the Wind turbine apprenticeship route. Candidates should not be registered if they hold from City & Guilds or another awarding body a qualification of a similar level and within the same content area.

Age restrictions

These Electrical Power Engineering qualifications are **not** approved for use by candidates under the age of 16, and City & Guilds cannot accept any registrations for candidates in this age group.

3 Assessment

3.1 Summary of assessment methods

The technical knowledge qualification is assessed through a combination of multiple choice and short answer written papers.

Below are a summary of the assessment methods for each unit

Unit 750 Health and safety in the power industry – **Short Answer Written Paper**
Unit 751 Theory and background of wind turbines and energy – **Short Answer Written Paper**
Unit 752 Mechanical theory and principles of wind turbine technology – **Short Answer Written Paper**
Unit 753 Electrical theory and principles of wind turbine technology - **Short Answer Written Paper**
Unit 754 Control and instrumentation theory and principles of wind turbine technology – **Short Answer Written Paper**
Unit 755 Hydraulic theory and principles of wind turbine technology – **Short Answer Written Paper**
Unit 756 Wind turbine systems technology – **Short Answer Written Paper**

Assessments will be produced by City & Guilds and internally marked. Assessments can be downloaded from the City & Guilds web page **www.cityandguilds.com** they have set grading criteria which can be found in the test specifications in the assessment pack.

Resits

Several versions of each question paper will be available. Candidates who fail any assessments will need to re-take the next version of the required assessment.

3.2 Recognition of prior learning (RPL)

Recognition of Prior Learning (RPL) is a process of using an individual's previous achievements to demonstrate competence. This is not a new process but expands on previously described terms like "the accreditation of prior learning (APL), the recognition of experimental learning or "the validation of informal learning" by incorporating all types of prior learning and training.

The Regulatory arrangements for the Qualifications and Credit Framework define RPL as follows:

- A method of assessment that considers whether a learner can demonstrate that they can meet the assessment requirements for a unit through knowledge, understanding or skills they already possess and do not need to develop through a course of learning.
- Assessment for RPL is conducted against the learning outcomes and assessment criteria of a unit and is subject to exactly the same quality assurance requirements as any other kind of assessment.
- 'RPL is the process of documenting, assessing, validating and certificating learning gained outside the formal education and training system'.

- The RPL process is relevant where an individual has previously learnt something but has never received formal recognition for this learning through a qualification or other form of certification.
- RPL refers to an opportunity for learners to present competence or knowledge evidence which comes from a period prior to their registration for a particular qualification.
- The evidence presented e.g. certificates, witness testimonies etc, will need to provide sufficient detail to allow the assessor to apply an RPL assessment process.
- Assessment staff to work through Learning Outcomes and Assessment Criteria ensuring that all are covered, using relevant methods for RPL such as: Witness Testimony, Reflective Accounts, Professional Discussion, etc.
- Unit is assessed using RPL (all learning will have been gained prior to registering for qualification).

4 Units

Structure of units

The units in this qualification are written in a standard format and comprise the following:

- unit accreditation number
- title
- level
- credit value
- unit aim
- information on assessment
- learning outcomes which are comprised of a number of assessment criteria
- notes for guidance.

Summary of units

Accreditation unit reference	City & Guilds unit number	Unit title	Credit value	Level	GLH
M/601/8927	Unit 750	Health and safety in the power industry	4	3	36
M/601/8930	Unit 751	Theory and background of wind turbines and energy	12	3	108
H/503/4340	Unit 752	Mechanical theory and principles of wind turbine technology	14	3	130
M/503/4390	Unit 753	Electrical theory and principles of wind turbine technology	15	3	140
D/601/8941	Unit 754	Control and instrumentation theory and principles of wind turbine technology	7	3	63
A/503/4392	Unit 755	Hydraulic theory and principles of wind turbine technology	14	3	130
T/601/8945	Unit 756	Wind turbine systems technology	12	3	108

Unit 750 Health and safety in the power industry

Level: **3**
Credit value: **4**
UAN: **M/601/8927**

Unit aim
This unit is designed to provide learners with a thorough understanding of health and safety requirements for the wider Power sector, along with Wind Industry - specific areas of importance.

It also covers areas on employment rights and responsibilities, legislation and the wider Power sector environment.

Learning outcomes
There are five learning outcomes to this unit. The learner will be able to:
1. Demonstrate an understanding of health and safety
2. Work effectively and develop competences
3. Demonstrate an understanding of industry and the environment
4. Demonstrate an understanding of employment rights & responsibilities
5. Demonstrate an understanding of industry specific legislation

Guided learning hours
It is recommended that **36** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Assessment
This unit will be assessed by a short answer written test

Unit 750 Health and safety in the power industry

Outcome 1 Demonstrate an understanding of health and safety

Assessment Criteria

The learner will be able to:

1.1 identify statutory regulations and organisational requirements for Health and Safety
1.2 list the roles and responsibilities of relevant Health and Safety organisations
1.3 state accident and emergency procedures
1.4 demonstrate and implement safe working practices with respect to safe working areas.
1.5 identify relevant safety and hazard warning signs.
1.6 identify the reasons for accidents happening and the importance of putting in place preventative measures
1.7 identify First Aiders, as well as situations where First Aid should be administered.
1.8 state how to isolate an electrical source safely in an emergency and non-emergency situation.
1.9 outline safety procedures when manually handling a range of products of different size, shape and weight.
1.10 outline safety procedures associated with mechanical and non-mechanical access equipment.
1.11 outline safety procedures when using mechanical lifting equipment.
1.12 define safe working procedures whilst operating in confined spaces.
1.13 identify hazards associated with fire.

Unit 750 Health and safety in the power industry
Outcome 2 Work effectively and develop competences

Assessment Criteria

The learner will be able to:

2.1 identify methods for working effectively and developing competences as individuals and groups.

2.2 list quality systems within working environments.

Unit 750 Health and safety in the power industry

Outcome 3 Demonstrate an understanding of industry and the environment

Assessment Criteria

The learner will be able to:

3.1 identify legislation associated with environmental issues

3.2 outline the impact the electricity industry is having on the environment.

Unit 750 Health and safety in the power industry

Outcome 4 Demonstrate an understanding of employment rights and responsibilities

Assessment Criteria

The learner will be able to:

4.1 identify legislation associated with Employment Rights and Responsibilities

4.2 outline the quality procedures associated with Employment Rights and Responsibilities.

Unit 750 Health and safety in the power industry

Outcome 5 Demonstrate an understanding of industry specific legislation

Assessment Criteria

The learner will be able to:

5.1 state the relevant statutory Acts and regulations with regard to Power sector

5.2 outline the requirements of relevant statutory Acts and regulations with regard to planning permission and highway authorities.

Unit 751 Theory and background of wind turbines and energy

Level: 3
Credit value: 12
UAN: M/601/8930

Unit aim
This unit is designed to allow learners the opportunity to demonstrate an understanding of electrical, mechanical, hydraulic and control & instrumentation knowledge of wind turbine systems.

Learners are required to identify individual systems and components of a wind turbine, as well as describing the basic functions and operations of a wind turbine.

Learning outcomes
There are seven learning outcomes to this unit. The learner will be able to:
1. Demonstrate an understanding of the wind and renewables industry
2. Demonstrate an understanding of aerodynamics
3. Demonstrate an understanding of meteorology
4. Demonstrate an understanding of types of wind turbines
5. Demonstrate an understanding of wind farms
6. Demonstrate an understanding of the operation of Wind Turbine systems
7. Demonstrate an understanding of the operation of a wind farm

Guided learning hours
It is recommended that **108** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Assessment
This unit will be assessed by a short answer written test

Unit 751 Theory and background of wind turbines and energy

Outcome 1 Demonstrate an understanding of the wind and renewables industry

Assessment Criteria

The learner will be able to:

1.1 discuss the political and economic **factors** affecting the wind and **renewables industry**

1.2 explain the environmental **impacts** of wind turbines and wind farms.

Range

Factors

International agreements and directives: current legislation UK and EU
British standards v European standards: environmental**,** planning**,** electrical**,** financial**,** safety
National grid – compliance, proximity, connectivity
Carbon footprint – manufacture, installation, operation & maintenance
Regional supply chains

Renewables industry

On and off shore wind farms, wave & tidal systems, anaerobic digestion plants, photovoltaic farms, hydro systems

Impacts

Environmental, visual, audible, electromagnetic effects – radar interference, habitats

Unit 751 Theory and background of wind turbines and energy

Outcome 2 Demonstrate an understanding of aerodynamics

Assessment Criteria

The learner will be able to:

2.1 explain the **principles of aerodynamics**

2.2 explain the **effects** of aerodynamics on **rotor blades**

2.3 explain the **effects** of aerodynamics on **wind turbines**.

Range

Principles of Aerodynamics

The physics of aerodynamics, blade descriptors, root, leading edge, trailing edge, tip, twist, profile (cross section), theory of lift and drag & stall, Betz's law, calculating the power from the wind, capacity factor, rotor blade testing

Effects (rotor blades)

Design of rotor blades, effects of the wind on the blade, reaction of the blade to the wind, differing pressures along blade length, vortex

Effects (wind turbines)

Blade configuration, blade shape, blade dimensions, hub height, efficiency, reliability, output

Unit 751 Theory and background of wind turbines and energy

Outcome 3 Demonstrate an understanding of meteorology

Assessment Criteria

The learner will be able to:

3.1 explain the **sources of wind** and its **effect** on wind turbines
3.2 explain the **principles of air** and its **effect** on wind turbines
3.3 discuss the **relationship between wind and air**
3.4 discuss the **effects of disturbed** and **undisturbed air**
3.5 understand the **performance of wind turbines** under different weather conditions.

Range
Sources of wind
Pressure differences, heating effect of the sun, differential heating of the earth's surface, energy balance, oceanic & atmospheric circulation, rotational effect of the earth, weather phenomena, local winds – katabatic, anabatic, valley, fohn, sea breeze, land breeze, mountain waves

Effect (on wind turbines)
Efficiency/in-efficiency, correct performance, under-performance, over-performance (cutting out), damage to components, reliability

Principles of air
Atmosphere: composition, properties
Pressure: units, systems & characteristics.
Temperature: units, heat transfer methods (conduction, convection, and radiation), insulation, diurnal variation, sea temperatures/atmospheric temperatures, density.

Effect (on wind turbines)
Efficiency, performance/output

Relationship between wind and air
Atmospheric stability and instability, connecting the free atmosphere to the boundary layer, Laminar and turbulent flow; gustiness, convection, local circulation/regional circulation/global circulation, urban climate/rural climate

Effects of disturbed air (disrupted wind)
Under performance, strain on component
Disturbed air due to the terrain; mountains, valleys, deserts, moor/scrubland
Disturbed air due to the windbreaks (obstacles): buildings and structures, forests & wood-lands, shelter belts.
Disturbed air due to the surface heating (thermal turbulence): time of day (diurnal), seasonal effect, latitude, cloud cover

Effects of undisturbed air
Optimum performance, smooth operation
Un Disturbed air due to the sea, flat ground, rotor sweep above friction layer

Performance of wind turbines (under different weather conditions)

- Calm weather – No output
- Low wind conditions – Below average performance.
- Moderate wind conditions - Average performance.
- Strong winds – Possible over-performance, risk of cut out,
- Gusts –Stress on components, possible temporary shutdown.
- Squalls - temporary over-performance, possible cut out.
- Lull - under performance
- Gales - Shut down, possible damage
- Hurricane conditions-Structural damage
- Snow & ice - Vibration, possible shut down, component damage.
- Lightning strikes - Damage to components.
- Extreme High & low temperatures - Overheating, overcooling - component damage.

Unit 751 Theory and background of wind turbines and energy

Outcome 4 Demonstrate an understanding of types of wind turbines

Assessment Criteria

The learner will be able to:

4.1 **differentiate** the difference between upwind and downwind
4.2 explain **relevant** technical specifications
4.3 differentiate the main **classifications** and **grades**
4.4 explain the **factors** affecting location of **types of wind turbines.**

Range

Differentiate

Compare the design principles of upwind Wind turbine generator (WTG), downwind WTG, synchronous generator, asynchronous generator general loading effects of the wind, efficiency variations, direct drive versus gear box

Relevant

Technical specifications of upwind, technical specifications of downwind, differences in operation against technical specifications

Classifications

Upwind WTG, downwind WTG, synchronous WTG, asynchronous WTG

Grades

Identification and differentiation of the main characteristics

- comparison of mode of operation
- suitability of the different types for the location
- suitability for required output

Factors

- The wind resource and predicted power output for the site
- The topography of the area proposed
- The electricity grid connection availability
- Flight paths for both military and civilian aircraft
- For off-shore wind farms - marine navigation
- Land availability
- The proximity to residential homes, schools and hospitals
- Sites of special scientific interest
- Visual impact – effect on the landscape
- Effects on the soil, such as erosion

- Noise and vibration impact
- Effect on local wildlife
- Economic impact
- Social impact
- Ecology and nature conservation
- Shadow flicker
- Effects on radar and telecommunications
- Traffic issues
- Ice throw

Types of wind turbines
Different types of turbine: horizontal axis, upwind, downwind, vertical axis, pitch and stall regulated turbines, direct drive, variable speed

Unit 751 Theory and background of wind turbines and energy

Outcome 5 Demonstrate an understanding of wind farms

Assessment Criteria

The learner will be able to:

5.1 identify the **components** of a wind farm
5.2 differentiate the differences in **on / off shore requirements**
5.3 describe the **factors** affecting assembly of a wind farm
5.4 summarise the **lifecycle** of a wind farm.

Range

Components

Haul roads, foundations, hard standing, towers, nacelles, hubs, blades, cabling, data communication systems, eg SCADA, transformer substation, main substation, grid connection point, remote control and monitoring centre, meteorology mast, anemometers, safety equipment, access equipment

On/offshore requirements

Inception
Planning
Construction
Operation/maintenance
Decommission/repowering

Factors

Contractual agreements, physical location, planning and environmental issues, pre and post contract planning issues, contract programme, sub contract, ground and sub sea conditions, component manufacture and lead time, component size and weight, transport, access routes, temporary works, infrastructural works, restricted working conditions (tide & traffic), prevailing weather conditions (location & season), local resources (labour plant materials), grid location and connectivity

Lifecycle

Pre Development Phase - site search and preliminary investigations/discussions and preparation of Environmental Impact Assessments (EIA)

Development Phase – Planning application and approval including grid connection approval, turbine tender, development of financial packages including green benefits.

Construction Phase – Actual build and commission of the farm.

Operation – Generation and maintenance of the farm

Decommissioning and return to original use

Unit 751 Theory and background of wind turbines and energy

Outcome 6 Demonstrate an understanding of the operation of wind turbine systems

Assessment Criteria

The learner will be able to:

6.1 describe all the **functions** and **systems** of a wind turbine

6.2 explain the **application** and **interaction** of all wind turbine systems.

Range

Functions

Conversion of kinetic energy to mechanical energy, conversion of mechanical energy to electrical energy, transfer of energy from turbine to electrical grid, monitoring of operational status gear drive systems, direct drive, indirect drive, control systems as fitted to wind turbine generator (WTG) electrical & electronic

Systems

Drive train, pitch system, yaw system, hydraulic system, electro mechanical systems, safety systems, control system circuits and operation data communication systems e.g. SCADA, local and remote monitoring circuits gear drive systems, direct drive, indirect drive, control systems as fitted to WTG's mechanical, hydraulic, electrical & electronic

Application

Sensors communication with Programmable Logic Controller (PLC), PLC analysis, verification of data, input to turbine systems, operational understanding of data communication systems e.g. Supervisory Control and Data Acquisition SCADA

Interaction

Sensors, effect of PLC to generation systems, fibre optic interfaces, hard wired interfaces, sensor status signals, mechanical interface, hydraulic interface, electrical interface, electronic interface, optimisation of operating parameters

Unit 751 Theory and background of wind turbines and energy

Outcome 7 Demonstrate an understanding of the operation of a wind farm

Assessment Criteria

The learner will be able to:

7.1 explain the **relationships** between the **components of a wind farm**

7.2 describe how wind farms **interface** with the grid

7.3 explain the **grid code compliance**

Range

Relationships

The interaction of the various components within the range to maximise wind generation and safely connect to the grid:
The output from the turbines is connected to the grid system
The grid supply is permanently connected when turbine is not generating
The grid supply used for excitation of some generators
Double fed induction generators help to reduce grid disturbances effects

Components of a wind farm (on shore systems and off shore systems)

Power cabling, control/monitoring cabling, power transformer, off-shore transformer substation, main substation, wind farm remote control and monitoring centre, grid connection point, generation system, transformer, switch gear, sub transmission systems, sub station, conductors, control station

Interface

Connection of wind turbine generator (WTG) to the grid system, understand about permanent connection even when not generating, excitation supply of certain asynchronous generators

Grid code compliance

There is an obligation on the distribution network operators by the national grid to ensure that any wind farm generator complies with the grid codes, which have been designed to allow for the development, maintenance and operation of an efficient co-ordinated and economical system for the transmission of electricity and to promote the security and efficiency of the power network system

Unit 751 Theory and background of wind turbines and energy

Supporting information

Guidance

The following topics should be covered at an introductory level when teaching the differences in on/off shore wind farms.

Learning outcome 5 Assessment criteria 5.2 and 5.4

In describing the differences between the on/offshore requirements for wind farms the candidate will have effectively summarised the lifecycle of a wind farm.

Learning outcome 5

Inception (included in range for on/off shore requirements): planning policy statements, environmental impact assessments, sea initiatives, Collaborative Offshore Wind Research into the Environment (COWRIE), topography including sea bed survey, ground conditions, life cycle costs

Planning (included in range for on/off shore requirements): life cycle costs, contractual and partnership working, site planning – turbine layout, delivery schedules and patterns, routes, bearing capacities, restrictions, cable and grid issues, transformers, health and safety

Pre constructional activities

Construction (included in range for on/off shore requirements): plant & components, storage versus lean delivery techniques, weather conditions, transport, loading areas and working space, highways, cable and grid issues, transformers, health and safety and haul roads, temporary accommodation, construction processes, commissioning

Operation/maintenance (included in range for on/off shore requirements): cable and grid issues, transformers, health and safety, temporary accommodation, commissioning maintenance

Decommission/re-powering (included in range for on/off shore requirements): cable and grid issues, transformers, health and safety.

Unit 752 Mechanical theory and principles of wind turbine technology

Level: 3
Credit value: 14
UAN: H/503/4340

Unit aim
This unit is designed to teach and embed the underpinning theory and principles of mechanical aspects of wind turbine operation and maintenance - a key knowledge area of the job of a wind turbine technician.

This unit is intended for delivery in the classroom and laboratory, with workshop exposure where relevant. It covers, among other things, principles, characteristics and fault finding.

Learning outcomes
There are seven learning outcomes to this unit. The learner will be able to:
1. Demonstrate an understanding of the principles of materials
2. Demonstrate an understanding of the principles of mechanical machines
3. Demonstrate and understanding of fixing and fastening
4. Demonstrate an understanding of the principles of lubrication
5. Demonstrate an understanding of fault finding on mechanical systems

Guided learning hours
It is recommended that **130** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Assessment
This unit will be assessed by a short answer written test

Unit 752 Mechanical theory and principles of wind turbine technology

Outcome 1 Demonstrate an understanding of the principles of materials

Assessment Criteria

The learner will be able to:
1.1 identify **common materials**
1.2 describe the common **tests on materials**
1.3 state **properties** and defects of materials
1.4 select materials for given **component** specifications.

Range
Common materials
Timber, concrete
Ferrous metals: carbon steel, alloy steel, stainless steel, tool steel, cast iron
Non-Ferrous metals
Pure metals: aluminium, copper, lead, zinc
Alloys: cast & wrought aluminium alloys, cast & wrought copper alloys, titanium & magnesium alloys, sintered bronze, bronze, brass, solder
Composite materials: glass fibre composites, carbon fibre composites, metal polymer, ceramics, cellular products (foam or sponge), rubber, gasket materials
Thermosetting plastics: phenolic/ tufnol/polyester resin/ epoxy resin
Thermoplastics: nylon/pvc/polythene/acrylic

Tests on materials
Destructive tests: tension test, compression test, shear test, bending test, torsion test, hardness test, impact test, fatigue test
Non-destructive tests: visual, crack test (penetrant), radiographic, magnetic, electrical, ultrasonic**,** hardness, surface roughness, proof tests, vibration, photo-elastic, photo-stress

Properties
Physical, mechanical, thermal

Component
Foundation, nacelle frame, hub, blade flange, blades, main-shaft, gearbox, bearings, driveshaft, generator, tower, nacelle framework, yaw gear

Unit 752 Mechanical theory and principles of wind turbine technology

Outcome 2 Demonstrate an understanding of the principles of mechanical machines

Assessment Criteria

The learner will be able to:

2.1 describe **efficiency** of machines in terms of **work and energy**

2.2 identify types of **machines and component parts**

2.3 **calculate energy inputs and outputs** of a machine.

Range

Efficiency

Understand units used to describe efficiency (usually %)

Work and energy

Potential & kinetic energy

Units used to describe work & energy

Work = Force x distance moved in direction of force (W= F x d Or W= F x s)

Machines and component parts

Levers-type1, 2, 3 (fulcrum, load, gears, wheel & axle, pulleys, screw, inclined plane

Calculate energy inputs and outputs

$$\text{Efficiency} = \frac{\text{Power Output}}{\text{Power Input}}$$

$$\eta = \frac{\text{P out}}{\text{P in}} \times 100\%$$

$$\text{Efficiency} = \frac{\text{MA}}{\text{VR}} \times 100\%$$

Unit 752 Mechanical theory and principles of wind turbine technology

Outcome 3 Demonstrate an understanding of fixing and fastening

Assessment Criteria

The learner will be able to:

3.1 explain different **techniques** required of mechanical tightening

3.2 identify the need and operation of **working devices**

3.3 identify correct **nuts and bolts** compatible with job specification.

Range

Techniques

Tractive compression, sealing of components, resisting shear stress, resisting spontaneous loosening, resisting dynamic loads

Working Devices

Hand wrench, shock wrench, impact wrench, power tightening tools, torque multiplier, angle torque gauge, manual torque wrench, hydraulic torque wrench, hydraulic bolt tensioner

Nuts and bolts

Grades of nuts & bolts, fastener materials and coatings, bolt & nut, stud with nut, stud with nut at both ends, hex bolts, torq screws, self tapping bolts, self tapping screws, self locking nuts, flange nuts, use of appropriate washers (plain, chamfered, belville, repair, locking, shake-proof)

Unit 752 Mechanical theory and principles of wind turbine technology

Outcome 4 Demonstrate an understanding of the principles of lubrication

Assessment Criteria

The learner will be able to:

4.1 identify **types of lubrication**
4.2 select correct **lubrication for specific situations**
4.3 describe the **properties of lubricants**
4.4 explain the **benefits of lubrication**.

Range

Types of lubrication
Full fluid film lubrication, boundary lubrication, elasto-hydrodynamic lubrication

Lubrication for specific situations
Pitch mechanism lubrication, gear mechanism lubrication, yaw mechanism lubrication, hydraulic component lubrication, assembly of components, release of seized components, offline lubrication

Properties of lubricants
Viscosity, viscosity index, cloud point, flash point, acid number, thermal stability, oxidation resistance

Benefits of lubrication
Reduced friction, improved efficiency, improved component life, reduced heat & thermal expansion

Unit 752 Mechanical theory and principles of wind turbine technology

Outcome 5 Demonstrate an understanding of fault finding on mechanical systems

Assessment Criteria

The learner will be able to:

5.1 read and interpret **diagrammatic information** related to fault finding on mechanical systems

5.2 **relate diagrammatic information to physical construction**

5.3 explain **techniques** for fault finding on mechanical systems

5.4 explain common **symptoms, faults** and **causes** on mechanical systems.

Range

Diagrammatic information

Technical drawings, technical specifications, assembly drawings, parts diagrams

Relate diagrammatic information to physical construction

Assembly drawings - dimensions, construction, parts diagrams- layout

Techniques

Inspect – sensory, test, diagnose, substitute

Symptoms

Vibration, noise, overheating

Faults

Premature wear, component failure, contaminated lubricant

Causes

Dirt, imbalance, corrosion, moisture, inadequate lubrication, incorrect assembly, misalignment, shock load, overload, moisture, lubricant breakdown

Unit 753 Electrical theory and principles of wind turbine technology

Level: 3
Credit value: 15
UAN: M/503/4390

Unit aim
This unit is designed to teach and embed the underpinning theory and principles of electrical aspects of wind turbine operation and maintenance - a key knowledge area of the job of a wind turbine technician.

This unit is intended for delivery in the classroom and laboratory, with workshop exposure where relevant. It covers, among other things, principles, characteristics and fault finding.

Learning outcomes
There are ten learning outcomes to this unit. The learner will be able to:
1. Demonstrate an understanding of D.C. circuit theory
2. Demonstrate an understanding of principles of magnetism and electro magnetism
3. Demonstrate an understanding of the principles of operation electrical systems
4. Demonstrate an understanding of single phase A.C. circuit theory
5. Demonstrate an understanding of three phase A.C. circuit theory
6. Demonstrate an understanding of circuit technology
7. Demonstrate an understanding of Electricity Supply Systems
8. Demonstrate an understanding of transformers and rectifiers
9. Demonstrate an understanding of Power Electronics
10. Demonstrate an understanding of fault finding on electrical systems.

Guided learning hours
It is recommended that **140** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Assessment
This unit will be assessed by a short answer written test

Unit 753 Electrical theory and principles of wind turbine technology

Outcome 1 Demonstrate an understanding of D.C. circuit theory

Assessment Criteria

The learner will be able to:

1.1 describe the **relationship** between voltage, current and resistance in a resistive D.C. network

1.2 **solve problems** on power and energy in D.C resistive system.

Range

Relationship

Voltage, current and resistance in Direct Current (D.C.) circuits using ohms law, Kirchhoff's laws

Problem solving

D.C. power and energy, series circuits, parallel circuits, effects of the temperature coefficient of resistance, temperature rise in resistor

Unit 753 Electrical theory and principles of wind turbine technology

Outcome 2 Demonstrate an understanding of principles of magnetism and electromagnetism

Assessment Criteria

The learner will be able to:

2.1 explain the **factors relating to the force acting on a current-carrying conductor** situated in a magnetic field

2.2 explain the **factors which relate to the generation of a sinusoidal voltage waveform**

2.3 discuss the **relationships** between electromagnetic properties.

Range

Factors relating to the force on a current carrying conductor
Flux density, conductor length and conductor current

Factors which relate to the generation of a sinusoidal voltage waveform
Flux density, conductor length, conductor velocity and conductor angle

Relationships
Faraday's law, Lenz's law, left and right hand rule, induction

Unit 753 Electrical theory and principles of wind turbine technology

Outcome 3 Demonstrate an understanding of the principles of operation electrical machines

Assessment Criteria

The learner will be able to:

3.1 explain the **design** and **feature** of different types of electrical machines

3.2 explain the essential **characteristics** of different electrical machines

3.3 select the appropriate **electrical machines** for specified industrial applications.

Range

Design

Principles used to meet the design criteria for motors and generators for specific functions

Feature

Required function and operational parameters, stator, rotor, poles, windings, physical relationship of windings, electrical relationship of windings, starting currents, running current, starting torque, operating speed and speed control

Characteristics

Direct current (D.C) motors, induction motors, synchronous motors, stepper motors, asynchronous generators and synchronous generators, motor performance under no-load, partial load, full load and over load conditions

Electrical machines

Motors for yaw drive, pitch mechanism, hydraulic pumps, single and polyphase motors, generators for power production: asynchronous and synchronous

Unit 753 Electrical theory and principles of wind turbine technology

Outcome 4 Demonstrate an understanding of single phase A.C. circuit theory

Assessment Criteria

The learner will be able to:

4.1 **determine current, voltage, power relationships** in an A.C circuit comprising resistance, inductance and capacitance connected in series and parallel.

Range

Determine current, voltage, power relationships

Voltage, current and power values for resistors, inductors, capacitors (R.L.C) series circuits
Voltage, current and power values for R.L.C parallel circuits
Voltage, current and power values for R.L.C series parallel circuits
Phasor diagrams for circuits with inductive reactance
Phasor diagrams for circuits with capacitive reactance
Phasor diagrams for resistive circuits with capacitive and inductive reactance
Leading and lagging power factor

Unit 753 Electrical theory and principles of wind turbine technology

Outcome 5 Demonstrate an understanding of three phase A.C. circuit theory

Assessment Criteria

The learner will be able to:

5.1 state the advantages of three phase over single phase

5.2 interpret voltage phasor diagrams for star and delta connected windings and determine their line and phase relationships

5.3 explain the **generation of a three phase voltage supply**

5.4 solve problems involving three phase balanced loads.

Range

Generation of a three phase voltage supply

The operation of generators Synchronous and Asynchronous (squirrel cage) and Doubly Fed Induction Generator (DFIG)

The rotating magnetic field and the induced electromotive force (emf)

Unit 753 Electrical theory and principles of wind turbine technology

Outcome 6 Demonstrate an understanding of circuit technology

Assessment Criteria

The learner will be able to:

6.1 identify correctly **electrical symbols**
6.2 interpret **electrical circuit diagrams**
6.3 convert electrical circuit diagrams to electrical wiring diagrams
6.4 construct and test an electrical circuit from wiring diagram
6.5 describe **electrical testing and methods,** including features and operation of measuring instruments

Range

Electrical symbols

Institute of Electrical Contractors (IEC) symbols for electrical components and devices
International Organisation for Standardisation (ISO) symbols for electrical components and devices

Electrical circuit diagrams

European wiring and circuit diagrams
NEMA wiring and circuit diagrams
The operation of the circuits and the function/ purpose of each component

Electrical testing and methods

Types of test instrument – analogue and digital
Operation of voltmeters, ammeters, Ohm meters
Multimeters, test probes, clamp ammeters
Test procedures for motors, generators, transformers, cables

Unit 753 Electrical theory and principles of wind turbine technology

Outcome 7 Demonstrate an understanding of Electricity Supply Systems

Assessment Criteria

The learner will be able to:

7.1 explain the **operation** of the electricity supply network

7.2 state the **reason for high voltage transmission n**etwork

7.3 describe the **functions and the relationship** between transmission and distribution systems

7.4 state the **reasons** for statutory limits on voltage and frequency

7.5 describe the **effects** of voltage drops and losses

7.6 explain why power stations are interconnected.

Range

Operation

Generation, transformation, primary transmission, secondary transmission, primary distribution, secondary distribution and tertiary distribution, overhead lines, underground cables, transformers, circuit breakers, system protection

Reason for high voltage transmission

Interconnected grid system, I^2R losses, meeting maximum demand requirements, system redundancy

Functions and the relationship

Reason for the transmission system, reason for the distribution system, interface between transmission and distribution, transmission substations, distribution substations

Reasons

Effects of variations in the voltage and frequency, statutory regulations, voltage permissible limits, frequency permissible limits, penalties

Effects

Voltage drops and losses in overhead lines, voltage drops and losses in underground cables, losses in transformers, losses in rotating machines, effects of large induction loads on the system

Unit 753 Electrical theory and principles of wind turbine technology

Outcome 8 Demonstrate an understanding of transformers and rectifiers

Assessment Criteria

The learner will be able to:

8.1 describe the **basic operation of a transformer**
8.2 describe the **basic operation of a rectifier**
8.3 describe the **relationship** between turns, voltage and current ratios
8.4 **interpret** output wave shapes of rectifier circuits.

Range

Basic operation of a transformer

Operation of power transformers, construction and operation of auxiliary transformers, voltage and current

Basic operation of a rectifier

Operation of single and three phase rectifier circuits, half wave rectifier, full wave rectifier, bridge rectifier

Relationship

Principle action of a transformer, mutual induction, Faraday's law, Lenz's law, turns ratio equation

Interpret

Single and three phase waveforms produced by
Half wave rectifier
Full wave rectifier
Full wave bridge rectifier
With and without capacitor input filters/smoothers

Unit 753 Electrical theory and principles of wind turbine technology

Outcome 9 Demonstrate an understanding of Power Electronics

Assessment Criteria

The learner will be able to:

9.1 explain the **function** of principal active devices used in control of electrical power flow

9.2 explain the **need and methods for protection** of the power devices

9.3 explain the typical **application** and operation of principal devices used in the control of electrical power flow

9.4 explain the **operation** of typical circuits used in the control of electrical power flow.

Range

Function

Passive and active power electronic devices, operation of the thyristor, triac, diac, filter circuits

Need for protection

Preventing damage to the power electronics, power electronic protection for abnormal operating conditions

Methods for protection

Crow bar circuits, overload devices – instantaneous and current over time, no volts relays, rate of change of frequency, fuses, circuit breakers

Application

Overvoltage and under-voltage protection, current limiting devices, power factor corrections

Operation

Open loop system

Closed loop system

Smoothing

Motor speed control

Unit 753 Electrical theory and principles of wind turbine technology

Outcome 10 Demonstrate an understanding of fault finding on electrical systems

Assessment Criteria

The learner will be able to:

10.1 determine diagrammatic information related to fault finding on electrical systems
10.2 relate diagrammatic information to physical construction
10.3 describe **techniques** for fault finding on electrical systems
10.4 describe common symptoms, **faults** and **causes** on electrical systems.

Range

Techniques

Fault diagnosis techniques, fault location techniques, fault finding charts

Faults

Three phase asymmetrical fault – earth fault on one phase, line to line fault, phase to phase fault, line to line to earth fault, three phase symmetrical fault, short circuit, open circuit

Causes

Breakdown of cable insulation, loss of continuity, overheating of components, loose terminations, malfunction of components, mechanical damages, water ingress

Unit 753 Electrical theory and principles for wind turbine technology

Supporting information

Guidance

Note that the industry standard is to transmit A.C rather than D.C

Note that learners should be provided with an awareness of the following: Transformer protection systems and oil sampling and diagnostics.

Learning outcome 8 Assessment criteria 8.2

An awareness of the following devices should be covered:

- Silicon Control Rectifier (SCR)
- Thyristors
- Diac
- Triac
- Insulated Gate Bi-polar Transistor (IGBT)

Unit 754 Control and instrumentation theory and principles of wind turbine technology

Level: 3
Credit value: 7
UAN: D/601/8941

Unit aim
This unit is designed to teach and embed the underpinning theory and principles of control and instrumentation aspects of wind turbine operation and maintenance - a key knowledge area of the job of a wind turbine technician.

This unit is intended for delivery in the classroom and laboratory, with workshop exposure where relevant. It covers, among other things, principles, characteristics and fault finding.

Learning outcomes
There are four learning outcomes to this unit. The learner will be able to:
1. Demonstrate an understanding of the principles of fibre optics
2. Demonstrate an understanding of telemetry
3. Demonstrate an understanding of data communications
4. Demonstrate an understanding of fault finding on control systems

Guided learning hours
It is recommended that **63** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Assessment
This unit will be assessed by a combination of short answer written test

Unit 754 Control and instrumentation theory and principles of wind turbine technology

Outcome 1 Demonstrate an understanding of the principles of fibre optics

Assessment Criteria

The learner will be able to:
1.1 identify the **components** of fibre optics
1.2 explain how fibre optics are manufactured
1.3 describe the **application** of fibre optics
1.4 explain the common **techniques** for inspection on fibre optics
1.5 identify **tools and equipment** specific to fibre optic repair
1.6 explain the **methods** of repairing fibre optic cabling
1.7 describe how to splice and join fibre optic cable
1.8 explain the theory of data transmission through a fibre link.

Range
Components
Network cable, patch cable, transmitter, laser, optical regenerator, optical receiver, photocell/photodiode, electronic amplifier
Glass, plastic, plastic-clad silica fiber (PCS), silicon and germanium, making the glass cylinder, drawing the fibre, testing the fibres, cladding

Application
Data transmission, multiplexing

Techniques
Inspection and testing of fibre optic cable and system, attenuation, bandwidth, signal degradation, tensile strength, refractive index profile, fibre geometry, information carrying capacity, chromatic dispersion, operating temperature, ability to conduct light underwater.

Tools and equipment
Splicer, cleaver, spectrometer

Methods
Optical fibre connectors, arc fusion splicing, mechanical splicing, reflection, refraction, clad and unclad fibre optic cable

Unit 754 Control and instrumentation theory and principles of wind turbine technology

Outcome 2 Demonstrate an understanding of telemetry

Assessment Criteria

The learner will be able to:
2.1 explain the **principles** of telemetry
2.2 identify **types** of transducers
2.3 describe the **factors** that affect the operation of transducers
2.4 identify **methods of measurement and data storage.**

Range
Principles
Continuous data stream, data quality, error detection and correction, multiple data sources

Types
Temperature transducers, pressure transducers, force transducers, piezoelectric transducers, magnetic transducers, vibration transducers

Factors
Incorrect positioning, mechanical damage, design faults, overload, component failure

Methods of measurement and data storage
Data comparison, data compression, electronic achieving

Unit 754 Control and instrumentation theory and principles of wind turbine technology

Outcome 3 Demonstrate an understanding of data communications

Assessment Criteria

The learner will be able to:
3.1 identify **techniques** for data communication
3.2 explain correct **protocols** used in data communication
3.3 explain correct **applications** of data communication.

Range
Techniques
Data collection, data analysis, data transmission, asynchronous verses, synchronous transmission

Protocols
Understand layering, flow control, error recovery, data encryption

Applications
Collecting real data, analogue signals, digital signals, control of noise and electrical distortion, data storage technology and retrieval

Unit 754 Control and instrumentation theory and principles of wind turbine technology

Outcome 4 Demonstrate an understanding of fault finding on control systems

Assessment Criteria

The learner will be able to:

4.1 read and interpret **diagrammatic information** related to fault finding on control systems
4.2 relate diagrammatic information to control systems
4.3 explain **techniques** for **fault finding** on control systems
4.4 recognise common **symptoms,** faults and causes on control systems

Range

Diagrammatic information

Read and interpret control system diagrams, identify control system components, understand purpose and operation of components

Techniques

Fault location techniques, functional test, unit substitution, input to output, half split technique, diagnostic techniques for fault causes

Fault finding

Understanding of control system operation and fault finding techniques

Symptoms

Fault finding charts, broken wires, faulty sensor, defective termination, bridges

Unit 755 Hydraulic theory and principles of wind turbine technology

Level: 3
Credit value: 14
UAN: A/503/4392

Unit aim
This unit is designed to teach and embed the underpinning theory and principles of hydraulic aspects of wind turbine operation and maintenance - a key knowledge area of the job of a wind turbine technician.

This unit is intended for delivery in the classroom and laboratory, with workshop exposure where relevant. It covers, among other things, principles, characteristics and fault finding.

Learning outcomes
There are seven learning outcomes to this unit. The learner will be able to:
1. Demonstrate an understanding of the basic physical principles of hydraulic fluids
2. Demonstrate an understanding of hydraulic principles
3. Demonstrate an understanding of the principles of hydraulic pumps and motors
4. Demonstrate an understanding of hydraulic actuators
5. Demonstrate an understanding of hydraulic accumulators
6. Demonstrate an understanding of fault finding on hydraulic systems
7. Demonstrate an understanding of health & safety in hydraulic systems

Guided learning hours
It is recommended that **130** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Assessment
This unit will be assessed by a short answer written test

Unit 755 Hydraulic theory and principles of wind turbine technology

Outcome 1 Demonstrate an understanding of the basic physical principles of hydraulic fluids

Assessment Criteria

The learner will be able to:
1.1 identify **types of fluids** used in hydraulic systems
1.2 describe **hydraulic fluid properties**
1.3 describe **environmental effects** on hydraulic fluids.

Range
Types of fluids
Mineral, fire resistant, synthetic

Hydraulic fluid properties
Viscosity, pour point, lubricating ability, oxidation resistance, rust & corrosion protection, demulsibility

Environmental effects
Causes of contamination-built in, ingressed, self generated, types of contamination – magnetic, material, liquid, particulate, component failure- catastrophic, intermittent, degradation

Unit 755 Hydraulic theory and principles of wind turbine technology

Outcome 2 Demonstrate an understanding of hydraulic principles

Assessment Criteria

The learner will be able to:

2.1 identify **hydraulic components** and **component symbols**
2.2 interpret **fluid power circuits**
2.3 explain the **design** and **assembly** of a hydraulic circuit.

Range

Hydraulic components

Reservoir, conditioning systems (heaters, coolers, filters), strainers, pumps & motors, control valves -directional, (linear & rotary), pressure - (fixed & variable), flow (fixed & adjustable), valve/actuator control devices (springs, levers, detents, solenoids, pilot, servo)

Pipes, hoses & fittings, actuators (rotary & linear)**,** rotary couplings**,** accumulators**,** sensors & switches**,** measuring devices-pressure gauge, flow meter

Component symbols

Reservoir, hydraulic lines, tubes & hoses, pumps, motors, cylinders, control valves (direction, check, shuttle, pressure, flow, shut off), valve control methods(manual, mechanical, electrical. pilot etc), accumulators, fluid conditioning (filter, heater, cooler), sensors, switches & gauges

Fluid power circuits

Pitch control, yaw control, brake circuits (rotor lock, shaft, yaw mechanism), safety back-up systems, offline systems, fluid conditioning systems

Design

Fluid storage & conditioning, system pressure & flow rates, friction & pressure losses, laminar & turbulent flow, pressure & flow control

Assembly

Pipes, hoses & connectors, fluid conditioning, fluid monitoring, vibration control

Unit 755 Hydraulic theory and principles of wind turbine technology

Outcome 3 Demonstrate an understanding of the principles of hydraulic pumps and motors

Assessment Criteria

The learner will be able to:

3.1 identify typical **hydraulic pump** and **motor design**

3.2 explain **characteristics of designs** of motors and pumps

3.3 explain correct **application** of hydraulic pumps and motors.

Range

Hydraulic pump

Gear, vane, piston pumps

Motor design

Gear, vane, piston motors

Characteristics of designs

Internal & external gear, balanced & un-balanced vane, radial & axial piston, fixed & variable

Application

Pitch & yaw system operation, main brake & yaw brake, rotor lock (hand pump)

Unit 755 Hydraulic theory and principles of wind turbine technology

Outcome 4 Demonstrate an understanding of hydraulic actuators

Assessment Criteria

The learner will be able to:

4.1 identify **mechanical aspects** of hydraulic actuators
4.2 identify typical **types of hydraulic actuators**
4.3 describe correct **application of hydraulic actuators**.

Range

Mechanical aspects

Rotary; housing, end plate, rotary element (gears/rotor), seals, bearing bushes, brake assembly (piston/ brake discs)

Linear**;** body, rod cap, end cap, piston, rod, seals (piston, rod, wiper), cushion, mounting brackets, clevis

Types of hydraulic actuators

Rotary; gear, vane, piston

Linear; single & double acting, differential & non-differential, spring return, cushion

Application of hydraulic actuators

Pitch control - linear

Yaw control - rotary

Brake operation (yaw, main-shaft, rotor lock)

Nacelle roof panels

Unit 755 Hydraulic theory and principles of wind turbine technology

Outcome 5 Demonstrate an understanding of hydraulic accumulators

Assessment Criteria

The learner will be able to:

5.1 identify **mechanical aspects** of hydraulic accumulators
5.2 identify typical **types of hydraulic accumulators**
5.3 describe correct **application of hydraulic accumulators**.

Range

Mechanical aspects

Piston type-Body, gas chamber, fluid chamber, piston, piston seal, gas valve, port
Bladder Type - Body, bladder, gas valve, poppet.
Diaphragm Type - Body, gas chamber, fluid chamber, diaphragm, gas valve.

Types of hydraulic accumulators

Piston accumulator, bladder accumulator, diaphragm accumulator

Application of hydraulic accumulators

Shock absorption, volume compensation, smooth out pulsation, system fail-safe

Unit 755 Hydraulic theory and principles of wind turbine technology

Outcome 6 Demonstrate an understanding of fault finding on hydraulic systems

Assessment Criteria

The learner will be able to:

6.1 determine **diagrammatic information** related to fault finding on hydraulic systems
6.2 **relate** diagrammatic information to physical construction
6.3 explain **techniques** for fault finding on hydraulic systems
6.4 describe common **symptoms, faults and causes** on hydraulic systems.

Range

Diagrammatic information
Specifications, circuit diagrams DIN ISO 1219, test procedures

Relate
Circuit diagrams, sectioned drawings, parts diagrams

Techniques
Sensory checks, inspect, test, hydraulic oil sampling techniques, fault finding charts

Symptoms
Noise, heat, leaks, lacquer and sludge, incorrect flow -no flow, low flow, excessive flow, incorrect pressure-no pressure, low pressure, erratic pressure, excessive pressure, faulty operation-no movement, slow movement, erratic movement, excessive speed or movement, contaminated oil, wear of components

Faults and Causes
Cavitation, air, worn valves, restricted filters, low oil level, valves worn or faulty, faulty oil cooler/heater, oil viscosity incorrect, worn pump, worn seals, loose components or joints, oil viscosity low, cracked components, oil temp high, contaminated oil, oil viscosity incorrect, blocked filter, sticking valves, relief valve faulty, relief valve set incorrectly, oil viscosity incorrect, pump/valve fault, valves sticking, seized/binding components, air in system, seal faults, incorrect oil viscosity, blown bladders

Unit 755 Hydraulic theory and principles of wind turbine technology

Outcome 7 Demonstrate an understanding of health & safety in hydraulic systems

Assessment Criteria

The learner will be able to:

7.1 explain the **main dangers** of high pressure systems
7.2 explain the main **environmental effects** of hydraulic fluids
7.3 explain **effects of human contact** with hydraulic fluids.

Range

Main dangers

High pressure fluid, high temperature oil, oil mist, dermatitis, flammable vapour

Environmental effects

Toxic**,** fouling of aquatic organisms**,** floats on water**,** not bio-degradable**,** slippery

Effects of human contact

Skin & eye irritation-dermatitis, oil mist/vapour can cause respiratory irritation, tissue damage if injected, blood poisoning & gangrene

Unit 755 Hydraulic theory and principles of wind turbine technology

Supporting information

Guidance

Learning outcome 2 Assessment criteria 2.2 and 2.3
Note that the circuits referred to in these criteria are not intended to be complex systems

Unit 756 Wind turbine systems technology

Level: 3
Credit value: 12
UAN: T/601/8945

Unit aim
This unit is designed to allow learners the opportunity to demonstrate an understanding of electrical, mechanical, hydraulic and control and instrumentation knowledge of wind turbine systems.

Learners are required to identify individual systems and components of a wind turbine, as well as describing the basic functions and operations of a wind turbine.

Learning outcomes
There are five learning outcomes to this unit. The learner will be able to:
1. Demonstrate an understanding of the mechanical operation of a wind turbine
2. Demonstrate and understanding of electrical operation of a wind turbine
3. Demonstrate and understanding of control & instrumentation operation of a wind turbine
4. Demonstrate and understanding of hydraulic operation of a wind turbine
5. Demonstrate and understanding of rotor blade operation of a wind turbine

Guided learning hours
It is recommended that **108** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Assessment
This unit will be assessed by a short answer written test.

Unit 756 Wind turbine systems technology

Outcome 1 Demonstrate an understanding of the mechanical operation of a wind turbine

Assessment Criteria

The learner will be able to:

1.1 identify individual mechanical **systems** and **components** in a wind turbine

1.2 describe the **basic mechanical functions** and **operations** of a wind turbine.

Range

Systems

Drive train layouts**,** power transfer systems
Wind Turbine Generator (WTG) control systems; power control, safety systems
WTG operational systems; monitoring, conditioning systems

Components

Drive shafts, clutches, couplings, gears, drive components, bearings, seals, brake callipers, brake pads, pitch mechanisms, yaw mechanisms, rotor lock mechanisms, pitch lock mechanisms
Gearbox oil conditioning systems; filters, pumps, coolers, heaters

Basic mechanical functions

Function of the mechanical systems on a WTG used to convert wind energy into mechanical energy.
Function of the mechanical systems on a WTG used to transfer mechanical energy to the generator.
Function of the mechanical systems of the WTG used to control the power output from the machine
Function of the mechanical systems which prevent damage to the WTG, personnel, and the associated systems

Basic mechanical Operations

Operation of the mechanical systems on a WTG used to control conversion of wind energy into mechanical energy.
Operation of the mechanical systems on a WTG used to transfer mechanical energy to the generator.
Operation of the mechanical systems of the WTG used to control the power output from the machine
Operation of the mechanical systems which prevent damage to the WTG, personnel, and the associated systems

Unit 756 Wind turbine systems technology

Outcome 2 Demonstrate an understanding of electrical operation of a wind turbine

Assessment Criteria

The learner will be able to:

2.1 identify individual electrical **systems** and **components** in a wind turbine

2.2 describe the **basic electrical functions** and **operations** of a wind turbine.

Range

Systems

Generation, control of electrical power, transmission of electrical power

Components

Synchronous generators, asynchronous generators, turbine power, transformers, auxiliary transformers, yaw motor, pitch motors, electrical cabinets, inverters, capacitors, programmable logic controller, anti-condensation heaters

Basic electrical functions

Principals of electrical engineering, principals of ac & dc machines, operations of components, methods of testing electrical components, methods of taking electrical measurement of components

Basic electrical operations

Transformers, motors, generators, transmission of output power, electrical circuits, electrical diagrams

Unit 756 Wind turbine systems technology

Outcome 3 Demonstrate an understanding of control & instrumentation operation of a wind turbine

Assessment Criteria

The learner will be able to:

3.1 identify individual control **systems** and **components** in a wind turbine

3.2 describe the **basic control functions** and **operations** of a wind turbine.

Range

Systems

Local control and monitoring, remote control and monitoring, system control and data analysis, data communication systems e.g. SCADA

Components

Photoelectric sensors, programmable logic controller (plc), angle of rotation detector, anemometer, wind vane, fibre optic coupling, vibration sensors, potential thermometers e.g. pt100, strain gauges

Basic control functions

Co-ordination and analysis of all output and input signals, anemometer, wind vanes, positioning sensors

Basic control operations

Control sequences, instructions from plc, rotor blade pitch mechanism, yaw mechanism, programmable logic controller, effects of faults and false readings, remote control centre

Unit 756 Wind turbine systems technology

Outcome 4 Demonstrate an understanding of hydraulic operation of a wind turbine

Assessment Criteria

The learner will be able to:

4.1 Identify individual hydraulic **systems** and **components** in a wind turbine

4.2 Describe the **basic hydraulic functions** and **operations** of a wind turbine.

Range

Systems

Power control systems; pitch, yaw, tip brake
Brake systems; drive, yaw, hub
On line filter systems & off line filter systems

Components

Fluid conditioning; reservoir, filters, pumps, heaters, coolers, accumulators

Fluid supply; pipe work, fittings, seals, drainage points, bleed points, hydraulic component electrical supply systems; mains, low voltage regulated power supply units, ac, dc

Fluid control valves; directional (manual, solenoid, pilot operated), pressure control, multi - port, pressure reducing, non-return, flow control.

Actuators; rotary, linear

Sensors; reed switch, pressure switch, inductive, micro-switch

System control devices; programmable logic controller (PLC), electro mechanical connections

Basic hydraulic functions

WTG hydraulic systems which operate power control systems – pitch, yaw, tip brake control
WTG hydraulic systems which operate safety systems-drive shaft brake, yaw system brake, rotor lock
WTG hydraulic system back up and safety control systems in event of power failure

Basic hydraulic operations

Hydraulic systems which operate WTG power control systems – pitch, yaw, tip brake control
Hydraulic systems which control WTG safety systems-drive shaft brake, yaw system brake, rotor lock
WTG hydraulic system back up and safety control systems

Unit 756 Wind turbine systems technology

Outcome 5 Demonstrate an understanding of rotor blade operation of a wind turbine

Assessment Criteria

The learner will be able to:

5.1 Identify the **types of plastics** used to manufacture rotor blades

5.2 Explain the **characteristics** and **design** of rotor blades.

Range

Types of plastics

Thermo plastics, thermoset plastics, glass reinforced plastic (GRP), additives, fillers, colorants, resins, strengthening fibres, mating, surface coating, finishing process, adhesives, elastomers. This may also include other materials such as foam, balsa, aluminium

Characteristics

Strength weight ratio, aerodynamic performance, stability performance, Betz law, power calculation, effects of damage on design

Design

Sandwich panel, solid laminate, types of rotor blade, shape of blade, stall type blade, pitch type blade, tip brake blade, testing methods and techniques, lightening protection methods, transportation, lifting

5 Course design and delivery

Initial assessment and induction

Centres will need to make an initial assessment of each candidate prior to the start of their programme to ensure they are entered for an appropriate type and level of qualification.

The initial assessment should identify:

- any specific training needs the candidate has, and the support and guidance they may require when working towards their qualification(s). This is sometimes referred to as diagnostic testing.
- any units the candidate has already completed, or credit they have accumulated which is relevant to the qualification(s) they are about to begin.

City & Guilds recommends that centres provide an induction programme to ensure the candidate fully understands the requirements of the qualification they will work towards, their responsibilities as a candidate, and the responsibilities of the centre. It may be helpful to record the information on a learning contract.

Typically, the phases of learning will incorporate (i) inductions (ii) unit-specific classroom and laboratory based learning and exercises (iii) assessment.

As a suggested guide to scheduling it is recommended that centres commence with the Health & Safety unit, followed by the respective core engineering units covering electrical, mechanical, hydraulics and control & instrumentation, with the wind turbine-specific units completing the course programme.

Further guidance about initial assessment and induction, as well as a learning contract that centres may use, are available on the City & Guilds website **www.cityandguilds.com**

6 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**.

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.

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.

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, Registrations/enrolment, Certificates, 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

If you have a complaint, or any suggestions for improvement about any of the services that City & Guilds provides, email: feedbackandcomplaints@cityandguilds.com

Published by City & Guilds
5-6 Giltspur Street
London
UK
EC1A 9DE
www.cityandguilds.com

City & Guilds is a registered charity established to promote education and training