

# **(SCQF) Level 6 Electrical Power Engineering - Wind Turbine Maintenance (Technical Knowledge) (2339-44)**

**Qualification handbook for centres**  
R095 04



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# SCQF Level 6 Diploma in Electrical Power Engineering - Wind Turbine Maintenance (Technical Knowledge) 2339-44

## Qualification handbook for centres

<b>Qualification title</b>	<b>Number</b>	<b>Accreditation Number</b>
SCQF Level 6 Diploma in Electrical Power Engineering – Wind Turbine Maintenance (Technical Knowledge)	2339-44	<b>R095 04</b>

<b>Version and date</b>	<b>Change detail</b>	<b>Section</b>
1.3 June 2012	Amended unit number 656, from 657	Units/656 unit title/Contents/ Qualification Structure/ Assessment
1.4 June 2012	Amend assessment types	Units 650 + 656
1.5 January 2016	Change in the City & Guilds Group statement Phone numbers deleted	Page 2 Useful contacts

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# 1 Introduction to the qualifications

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

<b>Qualification titles and levels</b>	<b>City &amp; Guilds qualification numbers</b>	<b>SQA accreditation number</b>
SCQF Level 6 Diploma in Electrical Power Engineering – Wind Turbine Maintenance (Technical Knowledge)	2339-44	R095 04

City & Guilds is proud to introduce for the emerging Renewables sector its first Modern Apprenticeship, designed specifically for Wind Turbine Service Technicians. This qualification, which delivers the underpinning knowledge component of the Apprenticeship, is accredited on the SCQF 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 - 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.

<b>Accreditation unit reference</b>	<b>City &amp; Guilds unit number</b>	<b>Unit title</b>	<b>Mandatory/ optional for full qualification</b>	<b>Credit value</b>	<b>Level</b>	<b>GLH</b>
U466 04	Unit 650	Health and safety in the power industry	Mandatory	4	6	36
U467 04	Unit 651	Theory and background of wind turbines and energy	Mandatory	12	6	108
U468 04	Unit 652	Mechanical theory and principles of wind turbine technology	Mandatory	9	6	81
U469 04	Unit 653	Electrical theory and principles for wind turbine technology	Mandatory	12	6	108
U470 04	Unit 654	Control and instrumentation theory and principles of wind turbine technology	Mandatory	7	6	63
U471 04	Unit 655	Hydraulic theory and principles of wind turbine technology	Mandatory	9	6	77
U473 04	Unit 656	Wind turbine systems technology	Mandatory	12	6	108

## 1.2 Opportunities for progression

On completion of the level 6 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:

<b>Description</b>	<b>How to access</b>
Assessments	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>
Unit handbook	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>

## 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 knowledge and/or industrial experience within the industry appropriate to these contexts – wind turbines.

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 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

<b>Accreditation unit reference</b>	<b>City &amp; Guilds unit number</b>	<b>Unit title</b>	<b>Credit value</b>	<b>Level</b>	<b>GLH</b>
U466 04	Unit 650	Health and safety in the power industry	4	6	36
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U470 04	Unit 654	Control and instrumentation theory and principles of wind turbine technology	7	6	63
U471 04	Unit 655	Hydraulic theory and principles of wind turbine technology	9	6	77
U473 04	Unit 656	Wind turbine systems technology	12	6	108

## Unit 650

## Health and safety in the power industry

**Level:** 6  
**Credit value:** 4  
**UAN:** U466 04

### 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.

**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 650**

### Outcome 2

## **Health and safety in the power industry**

### 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 650**

### Outcome 3

## **Health and safety in the power industry**

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 650**

Outcome 4

## **Health and safety in the power industry**

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 650**

Outcome 5

## **Health and safety in the power industry**

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 651

# Theory and background of wind turbines and energy

**Level:** 6  
**Credit value:** 12  
**UAN:** U467 04

### 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 651 energy

### Outcome 1

## Theory and background of wind turbines and

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 variance in energy related codes of practice, feed in tariffs, return on investment, regional pressure groups

#### 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 651

### Outcome 2

## Theory and background of wind turbines and energy

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 law, calculating the power from the wind, capacity factor, rotor blade testing

#### Effects (rotor blades)

Design of rotor blades, construction and material 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 651

# 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 651      **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

### **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 store regulated turbines, direct drive, variable speed

## Unit 651

# 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 e.g. 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

Decommissioning/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 651

## 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. 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 651

# 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 651      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.

**Inception|:** planning policy statements, environmental impact assignments, sea initiatives, cowrie, topography, ground conditions, life cycle costs

**Planning:** 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:** plant & components, storage v 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:** cable and grid issues, transformers, health and safety, temporary accommodation, commissioning maintenance

**Decommission/re-powering:** cable and grid issues, transformers, health and safety.

## Unit 652

# Mechanical theory and principles of wind turbine technology

**Level:** 6  
**Credit value:** 9  
**UAN:** U468 04

### 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 an 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 81 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 652

# 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 652

## 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-type 1, 2, 3 (fulcrum, load, gears, wheel & axle, pulleys, screw, inclined plane)

##### Calculate energy inputs and outputs

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

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

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

## **Unit 652                      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 652                      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 652

## 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 653

# Electrical theory and principles for wind turbine technology

**Level:** 6  
**Credit value:** 12  
**UAN:** U469 04

### 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 **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 653 Electrical theory and principles for 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, kirchoff'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 653

## Electrical theory and principles for wind turbine technology

### Outcome 2

Demonstrate an understanding of principles of magnetism and electro magnetism

#### 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**

Electromagnetic induction, magnitude of electro motor force (e.m.f) generated or induced in a coil, generation of e.m.f. in rotating magnetic field

#### Relationships

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

## Unit 653

# Electrical theory and principles for wind turbine technology

### Outcome 3

Demonstrate an understanding of the principles of operation electrical systems

#### Assessment Criteria

The learner will be able to:

- 3.1 explain the **design feature** of different types of motors and generators
- 3.2 explain the essential **characteristics** of different motors and generators
- 3.3 select the appropriate **motor and generator** for a specified industrial application
- 3.4 explain the electrical and mechanical **design** of cylindrical type electrical machines.

#### Range

##### Design feature

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

##### 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

##### Motor and generator

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

##### Design

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

## Unit 653

## Electrical theory and principles for 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 summarise the **relationships** between current and voltage in A.C. circuits containing resistance only, inductance only and capacitive only
- 4.2 **determine current, voltage, power relationships** in an ac circuit comprising resistance, inductance and capacitance connected in series and parallel.

#### Range

##### Relationships

Basic Alternating current (A.C.) circuits, Voltage and Current relationship

Laws of resistors in series and parallel

Laws of capacitors in series and parallel

Laws of inductors in series and parallel

##### 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 653

## Electrical theory and principles for 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 phase 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 (quirrel cage and DFIG )

The rotating magnetic field and the induced electro motor force (e.m.f.)

## **Unit 653                    Electrical theory and principles for 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**

British standard symbols for electrical components and devices

Institute of electrical contractors (IEC) symbols for electrical components and devices

National Engineering Manufacturers Association (NEMA) 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

Basic construction and operation of voltmeters, ammeters, ohm meters

Multimeters, test probes, clamp ammeters

Test procedures for motors, generators, transformers, cables

## Unit 653

# Electrical theory and principles for 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 network**
- 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, capacitance on overhead lines

## Unit 653

# Electrical theory and principles for 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

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

#### Basic operation of a rectifier

Construction and operation of single and three phase diode 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

## Unit 653

# Electrical theory and principles for 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 circuit  
Closed loop system circuit  
Smoothing circuits

## Unit 653

## Electrical theory and principles for wind turbine technology

### Outcome 10

Demonstrate an understanding of fault finding on electrical systems

#### Assessment Criteria

The learner will be able to:

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

#### Range

##### Understand techniques

Fault calculations, 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 653            Electrical theory and principles for wind turbine technology**

Supporting information

## **Guidance**

Learning outcome 7: Demonstrate an understanding of Electricity Supply Systems

Note that the industry standard is to transmit ac rather than dc

Learning outcome 8: Demonstrate an understanding of transformers and rectifiers

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

## Unit 654

# Control and instrumentation theory and principles of wind turbine technology

**Level:** 6  
**Credit value:** 7  
**UAN:** U470 04

### 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 short answer written test.

# Unit 651 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 (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 654

# 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 654            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 654

## 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 655

# Hydraulic theory and principles of wind turbine technology

**Level:** 6  
**Credit value:** 9  
**UAN:** U471 04

### 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 **77** 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 655

## 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 655                      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 655

## 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 655

# 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 655

# 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 655

# 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 read and interpret **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 recognise 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 655

## 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 655          Hydraulic theory and principles of wind turbine technology**

Supporting information

## **Guidance**

Learning outcome 2: Demonstrate an understanding of hydraulic principles

Note that in assessment criteria 2.2 and 2.3, the circuits referred to in these criteria are not intended to be complex systems

## Unit 656

## Wind turbine systems technology

**Level:** 6  
**Credit value:** 12  
**UAN:** U473 04

### 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 656 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 656

### Outcome 2

## Wind turbine systems technology

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 656

### Outcome 3

## Wind turbine systems technology

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 656

## 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 656

## 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, lightning protection methods, transportation, lifting

## 4 Assessment

### 4.1 Summary of assessment methods

The technical knowledge qualification is assessed through a combination of multiple choice and short answer written papers, along with practical assignments.

Below are a summary of the assessment methods for each unit

Unit 650 Health and safety in the power industry – **Short Answer Written Paper**

Unit 651 Theory and background of wind turbines and energy – **Short Answer Written Paper**

Unit 652 Mechanical theory and principles of wind turbine technology – **Short Answer Written Paper**

Unit 653 Electrical theory and principles of wind turbine technology – **Short Answer Written Paper**

Unit 654 Control and instrumentation theory and principles of wind turbine technology – **Short Answer Written Paper**

Unit 655 Hydraulic theory and principles of wind turbine technology – **Short Answer Written Paper**

Unit 656 Wind turbine technology systems approach – **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](http://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.

### 4.2 Recognition of prior learning (RPL)

Recognition of Prior Learning (RPL) is a process of using an individual's previous achievements to demonstrate competence within QCF. This is not a new process but expands on previously described terms like "the accreditation of prior learning (APL), the recognition of experiential 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.
- In the context of the QCF, the definition of RPL is quite specific and relates to assessment leading to the award of credit.
- 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 within the QCF.
- '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.
- Within the QCF an individual is able to 'claim' that he or she knows or can do something already and does not need to attend a course to learn it again. If he or she can prove this claim (through assessment of relevant evidence), then credit can be awarded for that achievement in the same way as any other credits. 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).

## 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](http://www.cityandguilds.com)

## 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](http://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 GOLLA assessments.

## Useful contacts

### UK learners

#### General qualification information

E: [learnersupport@cityandguilds.com](mailto:learnersupport@cityandguilds.com)

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### International learners

General qualification information

E: [intcg@cityandguilds.com](mailto:intcg@cityandguilds.com)

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### Centres

Exam entries, Registrations/enrolment, Certificates, Invoices, Missing or late exam materials, Nominal roll reports, Results

E: [centresupport@cityandguilds.com](mailto:centresupport@cityandguilds.com)

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### 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

E: [singlesubjects@cityandguilds.com](mailto:singlesubjects@cityandguilds.com)

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### International awards

Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports

E: [intops@cityandguilds.com](mailto:intops@cityandguilds.com)

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### Walled Garden

Re-issue of password or username, Technical problems, Entries, Results, GOLLA, Navigation, User/menu option, Problems

E: [walledgarden@cityandguilds.com](mailto:walledgarden@cityandguilds.com)

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### Employer

Employer solutions, Mapping, Accreditation, Development Skills, Consultancy

E: [business\\_unit@cityandguilds.com](mailto:business_unit@cityandguilds.com)

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### Publications

Logbooks, Centre documents, Forms, Free literature

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

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**Published by City & Guilds**  
**1 Giltspur Street**  
**London**  
**EC1A 9DD**  
**[www.cityandguilds.com](http://www.cityandguilds.com)**

A company registered in England and  
Wales (company number 16513878)