

Level 2 Certificate in Electrical Power Engineering – Distribution and Transmission (Technical Knowledge) (2339-17)

Qualification handbook for centres
500/9992/9



www.cityandguilds.com
July 2011
Version 2.0

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Contents

1	Introduction to the qualification	5
1.1	Qualification structure	6
1.2	Opportunities for progression	6
1.3	Qualification support materials	6
2	Centre requirements	7
2.1	Resource requirements	7
2.2	Candidate entry requirements	8
3	Assessment	9
3.1	Summary of assessment methods	9
3.2	Test specifications	9
3.3	Recognition of prior learning (RPL)	9
4	Course design and delivery	11
5	Units	12
Unit 660	Understand legislation in the power industry	13
Unit 661	Mathematics, mechanical and electrical theory in power engineering	26
Unit 662	Power engineering electrical networks, plant and apparatus	45
Unit 663	Power engineering: cables, sub stations and overhead lines	50
	Sources of general information	60

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1 Introduction to the qualification

This document contains the information (please consult the Walled Garden/Online Catalogue for last dates) that centres need to offer the following qualification:

Qualification title and level	City & Guilds qualification number	Qualification accreditation number
Level 2 Certificate in Electrical Power Engineering – Distribution and Transmission (Technical Knowledge)	2339-17	500/9992/9

This is a new qualification to support the Power Industry Distribution and Transmission apprenticeships at Level 2.

City & Guilds has been the proud provider of the power sector’s qualification and skills needs for many years and the 2339 is the new suite of competency-based qualifications for the UK power sector developed in close partnership with power sector employers and the Sector Skills Council Energy & Utility Skills (EU Skills).

This qualification has been accredited as a certificate on the QCF (Qualifications Credit Framework).

1.1 Qualification structure

This qualification is made up of four units of assessment; the learner must achieve 36 credits from the four units in the table below to achieve the full qualification.

Accreditation unit reference	City & Guilds unit number	Unit title	Mandatory/ optional for full qualification	Credit value	Level	GLH
R/601/8998	Unit 660	Understand legislation in the power industry	Mandatory	6	2	60
H/601/9007	Unit 661	Mathematics, mechanical and electrical theory in power engineering	Mandatory	12	2	120
M/601/9043	Unit 662	Power engineering electrical networks, plant and apparatus	Mandatory	9	2	90
H/601/9055	Unit 663	Power engineering: cables, sub stations and overhead lines	Mandatory	9	2	90

1.2 Opportunities for progression

On completion of the level 2 qualifications candidates may have the opportunity of progressing onto the following qualifications.

- Level 2 Diploma in Electrical Power Engineering - Substation Plant: 500/7322/9
- Level 2 Diploma in Electrical Power Engineering - Underground Cables: 500/7320/5
- Level 2 Diploma in Electrical Power Engineering - Overhead Lines: 500/7325/4
- Level 3 Diploma in Electrical Power Engineering - Substation Plant: 500/7323/0
- Level 3 Diploma in Electrical Power Engineering - Substation Plant: 500/7323/0
- Level 3 Diploma in Electrical Power Engineering - Underground Cables: 500/7324/2
- Level 3 Diploma in Electrical Power Engineering - Overhead Lines: 500/7318/7
- Level 3 Diploma in Electrical Power Engineering - Lead Substation Craftsperson: 500/7971/2
- Level 3 Diploma in Electrical Power Engineering - Lead Overhead Lines Person: 500/8007/6
- Level 3 Diploma in Electrical Power Engineering – Distribution and Transmission (Technical Knowledge) (Under development)

1.3 Qualification support materials

City & Guilds also provides the following publications and resources specifically for these qualifications:

Description	How to access
Assessment pack	www.cityandguilds.com
Qualification handbook	www.cityandguilds.com

2 Centre requirements

This section outlines the approval processes for centres to offer the Level 2 Certificate in Electrical Power Engineering – Distribution and Transmission (Technical Knowledge) and any resources that centres will need in place to offer the qualifications, including qualification-specific requirements for centre staff.

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 Skills' 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 be 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. Candidates should not be registered for these qualifications if they already hold a qualification of a similar level and within the same content area, from City & Guilds, or another awarding body.

Age restrictions

This qualification is not approved for use by candidates under the age of 16. City & Guilds cannot accept any registrations for candidates in this age group.

3 Assessment

3.1 Summary of assessment methods

For this qualification, learners will be required to complete the following assessments:

Unit No.	Title	Assessment Method	Where to obtain assessment materials
660	Understand legislation in the power industry	Multiple choice paper 201 This is a paper-based multiple-choice paper that is internally marked and externally verified.	Assessment pack is downloadable from www.cityandguilds.com
661	Mathematics, mechanical and electrical theory in power engineering	Multiple choice and short answer questions paper 202 This is a paper-based multiple-choice and short answer question paper that is internally marked and externally verified.	Assessment pack is downloadable from www.cityandguilds.com
662	Power engineering electrical networks, plant and apparatus	Multiple choice paper 203 This is a paper-based multiple-choice paper that is internally marked and externally verified.	Assessment pack is downloadable from www.cityandguilds.com
663	Power engineering: cables, sub stations and overhead lines	Multiple choice paper 204 This is a paper-based multiple-choice paper that is internally marked and externally verified.	Assessment pack is downloadable from www.cityandguilds.com

3.2 Test specifications

The test specifications for the units within this qualification are provided in the Assessment pack which is freely downloadable from the City & Guilds website **www.cityandguilds.com**

3.3 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).

In considering the appropriateness of any single piece of **evidence** the following should be considered:

- **Content** – the degree to which the content of any previous accredited learning meets the requirements of the National Occupational Standards against which it is being presented as evidence.
- **Comprehensiveness of assessment** – ensure that all learning derived for the content has been assessed. If only a proportion has been assessed, then the learning for the 'non-tested' areas cannot be assumed.
- **Level** – the degree to which the level of learning is offered and tested.
- **Performance and Knowledge** – the degree to which the previous learning covered both performance and knowledge. Some learning will only have offered and tested the latter, in which case the Recognition of Prior Learning can only cover this aspect. Performance will require further assessment. Although unlikely, the reverse (performance tested but not knowledge) could be true in which case knowledge and understanding would need further assessment.
- **Model of learning** – difficulties can arise in mapping learning gained from non-competence based learning programmes into competence based models.
- **Relevance of context** – the degree to which the context of the learning gained and assessed relates to the current context of candidate's work roles. If the context was different, the assessor will need to satisfy themselves of the candidate's ability to transfer the learning gained into their current setting.

4 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.

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**

5 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

City & Guilds unit number	Title	QCF unit number	Credits
660	Understand legislation in the power industry	R/601/8998	6
661	Mathematics, mechanical and electrical theory in power engineering	H/601/9007	12
662	Power engineering electrical networks, plant and apparatus	M/601/9043	9
663	Power engineering: cables, sub stations and overhead lines	H/601/9055	9

Level: 2
Credit value: 6
UAN number: R/601/8998

Unit aim

The learner will be able to demonstrate an understanding of the following when working in a power engineering environment:

- relative health, safety and environmental legislation, the use of method statements, codes of practice and risk assessments
- effective working management techniques to improve productivity of self and others
- methods of using and communicating technical information.

Learning outcomes

There are **twelve** learning outcomes to this unit. The learner will be able to:

1. Demonstrate an understanding of relevant health and safety legislation
2. Demonstrate an understanding of relevant health and safety procedures
3. Understand the risk assessment process
4. Understand the importance of Personal Protective Equipment (PPE)
5. Understand the causes of accidents
6. Understand the storage and inspection of lifting equipment
7. Understand about working at height
8. Understand about working in confined spaces
9. Understand fire prevention
10. Understand the importance of handling and disposing of waste
11. Understand the importance of working effectively and efficiently
12. Demonstrate an understanding of using and communicating technical information

Guided learning hours

It is recommended that **60** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Assessment

This unit will be assessed by:

- multiple choice written paper.

Unit 660

Outcome 1

Understand legislation in the power industry

Demonstrate an understanding of relevant health and safety legislation

Assessment Criteria

The learner can:

1. describe the employers and employees responsibilities relating to the following health and safety regulations:
 - a) Health and Safety at Work Act 1974
 - b) Electricity at Work Regulations 1989
 - c) Management of Health & Safety at Work Regulations 2003
2. outline the statutory requirements relating to the following health and safety regulations:
 - a) Electricity Supply, Quality and Continuity Regulations 2002
 - b) Manual Handling Operations Regulations 1992
 - c) Provision and Use of Work Equipment Regulations 1998
 - d) Noise at Work Regulations 1989
 - e) Display Screen Equipment Regulations 1992.

Unit 660
Outcome 2

Understand legislation in the power industry

Demonstrate an understanding of relevant health and safety procedures

Assessment Criteria

The learner can:

1. describe where to access sources of health and safety information and advice
2. state the roles and responsibilities safety officers/ representatives
3. state the roles, responsibilities and powers of Health and Safety Executive Inspectors
4. describe where you would find information relating to safety policies, codes of practice and procedures
5. outline the requirements of the Control of Substances Hazardous to Health Regulations 2002
6. identify relevant health and safety warning signs used in the power industry in relation to:
 - a) warning
 - b) prohibition
 - c) safe condition
 - d) mandatory safety signs.

Assessment Criteria

The learner can:

1. describe the reasons for reporting health and safety hazards
2. describe the reasons for carrying out risk assessments
3. define the terms 'hazard' and 'risk'
4. describe the principles of a risk assessment process to control hazards.

Unit 660

Outcome 4

Understand legislation in the power industry

Understand the importance of Personal Protective Equipment (PPE)

Assessment Criteria

The learner can:

1. describe why Personal Protective Equipment (PPE) should be stored, inspected and maintained correctly
2. outline the requirements relating to the Personal Protective Equipment at Work Regulations 1992.

Assessment Criteria

The learner can:

1. list the basic causes of accidents
2. outline the requirements relating to Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995
3. state the appropriate actions to be taken in the event of an injury / accident
4. describe the effects of electric shock
5. describe precautions which can be taken to prevent electric shock
6. state the difference between direct and indirect electrical contact.

Unit 660

Outcome 6

Understand legislation in the power industry

Understand the storage and inspection of lifting equipment

Assessment Criteria

The learner can:

1. describe why lifting equipment should be stored, inspected and maintained correctly
2. describe the meaning of these terms when using lifting equipment:
 - a) safe working load
 - b) maximum working load
3. outline the requirements of the Lifting Operations and Lifting Equipment Regulations 1998.

Assessment Criteria

The learner can:

1. describe the hazards associated with working at height
2. describe the preventative measures used to reduce the hazards of working at height (to stop or prevent cannot have both)
3. outline the requirements of the construction regulations with regard to work at height.

Unit 660
Outcome 8

Understand legislation in the power industry
Understand about working in confined spaces

Assessment Criteria

The learner can:

1. describe the hazards associated with working in confined spaces
2. outline the requirements of the Confined Spaces Regulations 1997.

Assessment Criteria

The learner can:

1. describe the conditions required for the combustion and extinction of fire with respect to:
 - a) heat
 - b) oxygen
 - c) fuel
2. describe methods of fire prevention
3. outline methods for controlling and extinguishing fires using suitable fire fighting equipment for different types of fires
4. describe the purpose and potential hazards of automatic fire fighting equipment
5. outline the requirements of the Fire Safety Regulations 2005.

Unit 660

Outcome 10

Understand legislation in the power industry

Understand the importance of handling and disposing of waste

Assessment Criteria

The learner can:

1. describe the importance of safely storing, handling and disposing of waste products.

Unit 660

Outcome 11

Understand legislation in the power industry

Understand the importance of working effectively and efficiently

Assessment Criteria

The learner can:

1. identify methods to assess own levels of competence and learning needs
2. describe how to plan and implement a timetable for developing competence and improve their personal performance
3. describe the principles and importance of team working
4. state the importance of effective communication in a working environment
5. describe how to plan work activities effectively and efficiently
6. list types of information needed to plan tasks effectively
7. outline basic principles for dealing with problems in planned activities
8. describe basic methods to evaluate the success of a completed planned activity
9. outline the benefits of improving working practices and procedures
10. describe the importance of meeting customer expectations
11. describe the impact of interruptions and loss of supply to customers.

Unit 660

Outcome 12

Understand legislation in the power industry

Demonstrate an understanding of using and communicating technical information

Assessment Criteria

The learner can:

1. describe the types of written technical information used in a power engineering environment
2. describe the types of diagrammatic / pictorial technical information used in a power engineering environment
3. identify the types of technical information which can be gained from geographic diagrams / site plans
4. describe the purpose of the given safety documents used in the power sector:
 - a) Permit to Work
 - b) Limitation of Access
 - c) Sanction for Test
5. describe the typical information contained in a Permit to Work
6. identify the range of customers encountered whilst working in the Power Sector
7. state the methods by which technical information can be communicated
8. describe the purpose of maintaining accurate system records
9. state how technical information can be recorded and stored
10. describe the importance of reporting technical information inconsistencies or inaccuracies to relevant parties
11. explain the importance of effective communication to maintain good relationships with customers.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Level: 2

Credit value: 12

NDAQ number: H/601/9007

Unit aim

The learner will be able to demonstrate:

- an understanding of the practical engineering application of addition, subtraction, division, multiplication, basic transposition and trigonometry
- an understanding of mathematical calculations in a power engineering environment
- an understanding of mechanical engineering principles, materials, equipment and techniques including, movement of loads, SI units, pulleys, transposition and application of basic formulae
- an understanding of the use of mechanical engineering principles and techniques in a power engineering environment
- an understanding of basic electrical principles including AC/DC theory, electrical dangers, simple circuits, magnetism, SI units, transformers and transposition and application of basic formulae
- an understanding of basic electrical principles and their application in a power engineering environment..

Learning outcomes

There are **seventeen** learning outcomes to this unit. The learner will:

1. Demonstrate an understanding of round numbers, use scientific notation, percentages and ratios
2. Demonstrate an understanding of areas, perimeters, volumes and surface areas of simple shapes
3. Demonstrate an understanding of scales, tables, graphs and charts
4. Demonstrate an understanding of Pythagoras' Theorem and sin/cos/tan in right-angled triangles
5. Demonstrate an understanding of substitute numerical values into simple engineering formulae
6. Demonstrate an understanding of the sequence of arithmetic operations
7. Define mass, force and weight
8. Define the parameters of mechanical systems
9. Define the components of hydraulic and pneumatic systems
10. Define statics and forces
11. Define energy, work and power
12. Define the parameters of material tensile strengths
13. Define the parameters of mechanical advantage
14. Understand the lever principle and theorem of movement
15. Demonstrate an understanding of circuit technology
16. Demonstrate an understanding of magnetism and electromagnetism
17. Demonstrate an understanding of transformers

Guided learning hours

It is recommended that **120** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Assessment

This unit will be assessed by:

- Multiple choice and short answer written paper.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 1

Demonstrate an understanding of round numbers, use scientific notation, percentages and ratios

Assessment Criteria

The learner can:

1. round a number to a given number of significant figures and/or decimal places
2. convert a number y from standard notation to scientific notation or vice versa
3. use a calculator to add or subtract or multiply or divide numbers in scientific notation
4. calculate a percentage of a quantity
5. calculate quantities linked by a given ratio and split a quantity correctly according to a given ratio.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 2

Demonstrate an understanding of areas, perimeters, volumes and surface areas of simple shapes

Assessment Criteria

The learner can:

1. calculate areas and perimeters of squares or rectangles or triangles or circles
2. calculate volumes and surface areas of cubes or cuboids or cylinders or (other) prisms of spheres.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 3

Demonstrate an understanding of scales, tables, graphs and charts

Assessment Criteria

The learner can:

1. extract information from a scale
2. extract information from a table
3. extract information from a graph
4. extract information from a chart.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 4

Demonstrate an understanding of Pythagoras' Theorem and sin/cos/tan in right-angled triangles

Assessment Criteria

The learner can:

1. use Pythagoras' Theorem correctly to calculate an unknown side in a right-angled triangle
2. use sine or cosine or tangent correctly to calculate an unknown side and angle in a right-angled triangle.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 5

Demonstrate an understanding of substitute numerical values into simple engineering formulae

Assessment Criteria

The learner can:

1. substitute numerical values into engineering formulae involving addition or subtraction or multiplication or division of terms, and combinations of these operations
2. substitute numerical values into engineering formulae involving simple powers: squares or square roots or cubes or cube roots.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 6

Demonstrate an understanding of the sequence of arithmetic operations

Assessment Criteria

The learner can:

1. perform a sequence of arithmetic operations following the form BODMAS
2. use a range of functions found on a calculator (non VPAM)
3. demonstrate the use of minus sign preceding numbers and number scale.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 7

Define mass, force and weight

Assessment Criteria

The learner can:

1. describe the differences and relationship between mass, force and weight
2. perform calculations using equations and SI units
3. represent force as a vector quantity.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 8

Define the parameters of mechanical systems

Assessment Criteria

The learner can:

1. identify the function of gears, levers, toggles, cams, cranks and pawl and ratchet
2. identify types of springs and their characteristics.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 9

Define the components of hydraulic and pneumatic systems

Assessment Criteria

The learner can:

1. identify hydraulic and pneumatic components
2. describe the function of hydraulic and pneumatic components.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 10

Define statics and forces

Assessment Criteria

The learner can:

1. identify conditions for static equilibrium, parallelogram of forces, triangle of forces, polygon of forces, following:
 - a) principles of moments
 - b) frictional resistance to motion
 - c) data to determine resultants
 - d) equilibrants and reactions
2. describe the states of equilibrium of a body and the effect of its centre of gravity in relation to overhead line structures
3. describe the effect the width of base, weight and centre of gravity have on a body's stability.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 11

Define energy, work and power

Assessment Criteria

The learner can:

1. describe the terms energy, work and power
2. define work as force times distance moved in the direction of the force
3. perform calculations for energy work and power using equations and SI units.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 12

Define the parameters of material tensile strengths

Assessment Criteria

The learner can:

1. identify the tensile strength of differing conductor types given relevant data
2. identify the sag of a conductor using:

$$T = \frac{WL^2}{8S}$$

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 13

Define the parameters of mechanical advantage

Assessment Criteria

The learner can:

1. describe mechanical advantage provided by the use of winches and pulley systems.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 14

Understand the lever principle and theorem of movement

Assessment Criteria

The learner can:

1. describe the lever principle and theorem of movement
2. explain practical application in the following : crowbars, pliers, cranes and winches of the lever principle
3. describe and calculate – mechanical advantage, velocity ratio and torque turning force
4. calculate efficiency as a percentage using input and output power or energy.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 15

Demonstrate an understanding of circuit technology

Assessment Criteria

The learner can:

1. describe electron theory and current flow
2. describe the basic electrical theory
3. define resistance
4. use graphs to evaluate resistive circuits
5. read data from graphs and evaluate their statistical relevance.
6. state the meaning of gradient on straight-line graphs
7. plot graphs showing:
 - a) inverse relationships
 - b) graphs of resistance
 - c) cross-sectional area
8. determine resistance from dimensions and resistivity
9. state the effect of temperature on the resistance of common conducting and insulating materials
10. use graphs to show what is meant by positive and negative temperature coefficients and indicate their uses
11. state the effects of applying a DC source to a resistance with respect to Ohm's Law
12. outline the difference between:
 - a) series
 - b) parallel
 - c) series/parallel resistive circuits
13. explain the meaning of voltage drop relative to conductors / cables
14. determine the voltage drop created by the simple connection of combinations of resistors
15. determine the current, voltage and power in circuits (and parts of circuits) formed by simple combinations of resistors
16. state the importance of voltage rating in respect to conductors, cables and transformers
17. identify the constructional features of the following:
 - a) parallel plate capacitor
 - b) variable and semi-variable air-spaced
 - c) solid dielectric types of capacitor
18. describe the principles and effect of capacitance relative to conductors / cables
19. describe the safety, charge and discharge characteristics of a capacitor relative to conductors / cables
20. describe the principles and effect of inductance relative to conductors / cables / steelwork.

Unit 661

Mathematics, mechanical and electrical theory in power engineering

Outcome 16

Demonstrate an understanding of magnetism and electromagnetism

Assessment Criteria

The learner can:

1. describe the theory relating to magnetic fields and their effects on overhead and underground cables
2. describe the characteristics of magnets
3. describe the laws relating to their resultant magnetic fields
4. state the relationship between magnetic field strength and relative areas of magnetic poles
5. explain electromagnetism
6. identify what happens to a magnetic field when a conductor carries current in relation to transformers
7. describe the forces exerted on a current carrying conductor
8. describe how magnetic forces can be reduced on underground and overhead cables
9. describe the dangers of switching inductive circuits
10. describe the movement caused to an armature when applying a DC current to a coil
11. with reference to given sketches, identify how magnetic shielding is provided in power engineering plant and apparatus.

Unit 661 Mathematics, mechanical and electrical theory in power engineering

Outcome 17 Demonstrate an understanding of transformers

Assessment Criteria

The learner can:

1. describe the operation and construction of a variety of power transformers
2. identify transformers from given sketches
3. identify the laminations, core, limb and yoke and state the function of each feature
4. compare hysteresis and eddy current losses
5. compare the construction of the auto-transformers and double-wound transformers
6. describe the operation and construction of instrument transformers
7. differentiate between iron and copper losses
8. state the relationship between input, output and losses
9. describe how losses may be reduced with respect to laminating the iron core
10. carry out basic mathematical analysis on transformers and perform simple calculations on input, output and losses
11. use percentages, when defining efficiency and losses within a transformer
12. perform the calculations involving current, voltage and turns based on an ideal transformer using the equation below in relation to transformer tap changers.

$$\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}$$

Unit 662

Power engineering electrical networks, plant and apparatus

Level: 2

Credit value: 9

NDAQ number: M/601/9043

Unit aim

The learner will be able to demonstrate:

- an understanding of power engineering electrical networks including; generation, transmission, distribution and transformation of system voltages
- an understanding of power engineering electrical plant and apparatus including the properties and purpose of transformers, switchgear, earthing devices, voltage and load control and automated equipment
- an understanding of the types, properties and use of power engineering electrical transmission and distribution plant and apparatus
- an understanding of power engineering common network configurations, terms and characteristics, switching operations, safety documentation and protection.

Learning outcomes

There are **four** learning outcomes to this unit. The learner will be able to:

1. Demonstrate an understanding of power generation
2. Demonstrate an understanding of power transmission and distribution
3. Demonstrate an understanding of electrical plant and apparatus
4. Demonstrate an understanding of electrical network operations

Guided learning hours

It is recommended that **90** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Assessment

This unit will be assessed by:

- Multiple choice written paper.

Unit 662

Power engineering electrical networks, plant and apparatus

Outcome 1

Demonstrate an understanding of power generation

Assessment Criteria

The learner can:

1. list the energy sources that can be used when generating electricity
2. describe how energy is converted into electrical power in the generation process using a range of energy sources
3. state why power stations are interconnected and the advantages of interconnection
4. identify the relationship between generation, transmission and distribution companies within the UK
5. describe the function of the Electricity Regulator in the UK.
6. describe the reasons for high voltage transmission and lower voltage distribution
7. describe the transmission to distribution process from high voltage to low voltage and identify the common voltage levels at each transitional stage
8. describe the function of a step down transformer in the transmission and distribution of electricity
9. describe the function of a step up transformer in the transmission and distribution of electricity.

Unit 662

Power engineering electrical networks, plant and apparatus

Outcome 2

Demonstrate an understanding of power transmission and distribution

Assessment Criteria

The learner can:

1. describe the advantages and disadvantages of using overhead line conductors to transmit / distribute electricity
2. describe the advantages and disadvantages of using underground cables to transmit / distribute electricity
3. describe the term Protective Multiple Earthing (PME)
4. describe the term Separate Neutral Earthing (SNE / TNS)
5. describe the construction and application of high voltage fuses used to protect networks
6. describe the construction and application of low voltage fuses used to protect networks
7. explain the usage of protection schemes on electrical networks.

Unit 662

Power engineering electrical networks, plant and apparatus

Outcome 3

Demonstrate an understanding of electrical plant and apparatus

Assessment Criteria

The learner can:

1. state the constructional features and cooling arrangements of distribution and transmission transformers
2. describe the relationship between a transformer's ratio of primary and secondary windings and how they affect the output voltage
3. state the function of a transformer tap changer
4. describe the function of the following types of apparatus:
 - a) voltage transformer
 - b) current transformer
 - c) liquid earthing resistor
 - d) fault thrower
5. describe the function of the following types of electrical plant and apparatus:
 - a) circuit-breakers
 - b) switches
 - c) isolators
 - d) busbars
 - e) switch fuse
6. describe the constructional features and the principles of switchgear operation
7. identify electrical plant and apparatus symbols on a given network diagram
8. state the function of high voltage surge arrestors
9. describe the purpose of earthing plant and apparatus
10. identify the methods for measuring the earth resistance value of plant and apparatus
11. state the importance of achieving the correct resistance value when testing earth resistance values
12. describe how fuses are used to protect electrical plant and apparatus
13. describe what is meant by the term 'fuse rating'
14. interpret a fuses rating and characteristics from given specification data.

Unit 662

Power engineering electrical networks, plant and apparatus

Outcome 4

Demonstrate an understanding of electrical network operations

Assessment Criteria

The learner can:

1. identify electrical plant and apparatus symbols on a given network diagram
2. describe the characteristics and function of electrical power networks in relation to:
 - a) radial circuits
 - b) ring circuits
 - c) feeder circuits
3. describe the methods of sectionalising a network
4. describe the common causes and types of network faults
5. describe the basic procedures for carrying out the isolation of :
 - a) a low voltage overhead line operating under 1000v
 - b) a high voltage overhead line operating over 1000v
 - c) a low voltage underground cable operating under 1000v
 - d) a high voltage underground cable operating over 1000v
6. describe the purpose of safety documentation in a power engineering environment
7. describe when each of the following safety documents would be used
 - a) Permit to Work
 - b) Limitation of Access / Limited Work Certificate
 - c) Sanction for Test
8. describe the basic roles and responsibilities of persons carrying out operations on an electrical network
9. state the purpose of network protection
10. list the types of protective systems used to protect electrical networks
11. state the advantages of carrying out network operations using remotely operated equipment
12. describe the methods by which network equipment can be remotely operated.

Unit 663

Power engineering: cables, sub stations and overhead lines

Level: 2

Credit value: 9

NDAQ number: H/601/9055

Unit aim

The learner will be able to demonstrate an understanding of the types and characteristics of:

- common cables and joints, including causes and consequences of common faults
- the types and characteristics of common substation plant and apparatus including causes and consequences of common faults
- common overhead line plant and apparatus including causes and consequences of common faults.

Learning outcomes

There are **nine** learning outcomes to this unit. The learner will:

1. Demonstrate an understanding of underground cables
2. Demonstrate an understanding of underground cable installations
3. Demonstrate an understanding of underground cable testing and common faults
4. Demonstrate an understanding of substation installations
5. Demonstrate an understanding of substation insulating mediums
6. Demonstrate an understanding of substation transformer protection
7. Demonstrate an understanding of substation maintenance
8. Demonstrate an understanding of overhead lines
9. Demonstrate an understanding of common faults on overhead lines

Guided learning hours

It is recommended that **90** hours should be allocated for this unit, although patterns of delivery are likely to vary.

Assessment

This unit will be assessed by:

- Multiple choice written paper.

Unit 663

Power engineering: cables, sub stations and overhead lines

Outcome 1

Demonstrate an understanding of underground cables

Assessment Criteria

The learner can:

1. state the types of underground cables used in UK Electrical Power Networks
2. describe the construction of the following types of cable including their core, insulation, sheathing and armouring arrangements
3. describe the common types and usage of joint used in underground cable installations
4. describe the advantages and disadvantages of different insulation materials
5. identify the electrical ratings of cables from given specifications / charts
6. describe the factors which affect the rating of a cable
7. describe the effects of electric stress on underground cables
8. explain how electrical stress can be reduced and controlled in underground cables.

Unit 663

Power engineering: cables, sub stations and overhead lines

Outcome 2

Demonstrate an understanding of underground cable installations

Assessment Criteria

The learner can:

1. state the requirements of the health and safety guidance note HSG 47 in relation to the safe working methods of cable identification, location and excavation
2. state the codes of practice and legal requirements that must be followed when carrying out cable laying activities
3. explain the advantages and disadvantages of direct lay and draw-in systems
4. state the factors to be recorded when a cable is laid
5. describe the benefits of keeping cable records and data
6. interpret and identify given information from cable plans / records
7. identify the hazards in the usage of cold pour resin in jointing activities
8. describe the precautions to be taken when handling cold pour resins.

Unit 663

Power engineering: cables, sub stations and overhead lines

Outcome 3

Demonstrate an understanding of underground cable testing and common faults

Assessment Criteria

The learner can:

1. describe the term 'phasing out' when jointing cables
2. describe the purpose for using test lamps when jointing cables
3. describe the purpose of bonding underground cables when jointing cables
4. state the causes of common cable faults
5. describe the meaning of the given terms:
 - a) open circuit
 - b) short circuit
 - c) earth faults
 - d) high resistance
6. describe the reason for 'cable spiking' an underground cable
7. describe the types and purpose of electrical testing when carrying out jointing activities.

Unit 663

Power engineering: cables, sub stations and overhead lines

Outcome 4

Demonstrate an understanding of substation installations

Assessment Criteria

The learner can:

1. identify the typical plant and apparatus used in a primary and secondary sub-station installations
2. describe the function of plant and apparatus used in primary and secondary sub-station installations
3. describe the type and use of tap-changers in relation to substation installations
4. describe the primary reason for the earthing of the neutral point in high voltage and low voltage systems
5. describe the purpose of neutral earthing resistors
6. describe the purpose of an earthing transformer
7. explain the reason for bonding and earthing of metalwork
8. describe the purpose of a Fault Thrower Switch (FTS)
9. describe the reason for measuring the earth resistance value of earth electrodes in substation installations
10. describe the meaning of the terms:
 - a) earth resistance
 - b) earth resistivity
 - c) earth fault loop impedance
11. interpret basic substation installation connections using given single line diagrams
12. describe the reasons for interlock systems and mechanisms used in substation installations
13. differentiate between the use of a bus section and bus coupler switches.

Unit 663

Power engineering: cables, sub stations and overhead lines

Outcome 5

Demonstrate an understanding of substation insulating mediums

Assessment Criteria

The learner can:

1. state the types of insulating mediums used in substation plant and apparatus
2. describe the function of insulating mediums used in substation plant and apparatus
3. describe the purpose of testing insulating mediums in electrical plant and apparatus.

Unit 663

Power engineering: cables, sub stations and overhead lines

Outcome 6

Demonstrate an understanding of substation transformer protection

Assessment Criteria

The learner can:

1. describe the construction and operation of a Buchholz relay
2. describe the construction and principles of transformer winding temperature
3. state the reasons for earthing the core and secondary windings in voltage and current transformers.

Unit 663

Power engineering: cables, sub stations and overhead lines

Outcome 7

Demonstrate an understanding of substation maintenance

Assessment Criteria

The learner can:

1. describe the advantages of preventative maintenance.

Unit 663

Power engineering: cables, sub stations and overhead lines

Outcome 8

Demonstrate an understanding of overhead lines

Assessment Criteria

The learner can:

1. explain statutory consents and notices and the procedures to be followed in the planning of overhead lines
2. outline topographical features that effect the routing of overhead lines
3. describe way-leave procedures (right grantors, notices, access, tree preservation orders, damage and compensation) in relation of overhead line planning
4. compare the advantages and disadvantages of different types of overhead line support and identify the differing voltage ranges they may support
5. in relation to overhead line design, describe the purpose of different support configurations and associated items
6. describe the construction and characteristics of a range of overhead line conductors
7. state the standard sizes, names and the typical voltage for which they are used, for a range of common overhead line conductors
8. describe the purpose of overhead line conductor joints and the crucial procedures of conductor preparation and connection
9. state the regulatory conductor ground clearances and conductor spacing for a range of common overhead line voltages
10. state, in general terms, the effect on conductors of span length, tension, temperature, wind and ice
11. state the constructional features for given types of insulator and state their purpose
12. describe the purpose and effect of applying earthing devices to an overhead line when it has been isolated.

Unit 663

Power engineering: cables, sub stations and overhead lines

Outcome 9

Demonstrate an understanding of common faults on overhead lines

Assessment Criteria

The learner can:

1. state the typical causes and symptoms of common faults on overhead lines
2. in relation to overhead lines, explain given overhead line terms and their possible cause.

Sources of general information

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

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

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

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

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

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

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

- ***Walled Garden***
Find out how to register and certificate candidates on line
- ***Qualifications and Credit Framework (QCF)***
Contains general guidance about the QCF and how qualifications will change, as well as information on the IT systems needed and FAQs
- ***Events***
Contains dates and information on the latest Centre events
- ***Online assessment***
Contains information on how to register for GOLA assessments.

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Useful contacts

UK learners

General qualification information

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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

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F: +44 (0)20 7294 2413

E: centresupport@cityandguilds.com

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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

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Walled Garden

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