Unit 53: Electrical Installation

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

We all use electricity almost without thinking about it. Although we are surrounded by and rely on electrical appliances, most people have little understanding of how electricity arrives at its final point of use.

This unit will give learners an understanding of the circuits regularly found in domestic premises, the components and accessories used, cables, sockets and light switches, etc. They will also gain some practical experience of constructing and investigating some of these circuits and systems. The unit will provide an understanding of installations where there is an increased shock risk, mainly to illustrate the hazards associated with these areas.

Safety and safe working practices are essential to reduce the risks of working with electricity to an absolute minimum. Learners will gain a knowledge of selecting types of cable for their insulation properties, current carrying capacity and physical strength, and choosing the correct type and rating of protective devices to prevent over-current. Learners will also be introduced to how the design and provision of earth bonding conductors helps prevent electric shock.

Learning outcomes

On completion of this unit a learner should:

1 Be able to interpret lighting and power circuits diagrams

2 Understand the methods used to protect circuits

3 Be able to install and test lighting and power circuits

4 Know the non-statutory and statutory regulations relating to the provision of an electrical installation.

Unit content

1 **Be able to interpret lighting and power circuits diagrams**

Lighting circuits: eg one way, two way (loop-in method, junction box, singles)

Power circuits: eg fused plug socket outlet, ring circuit, radial circuit, switched fused spur, cooker, immersion heater, heating control

Choice of cables and protection devices: cable calculations eg design current, correction factors, tabulated cable ratings and voltage drops; maximum demand and diversity eg determination and application of maximum demand and diversity (individual householder, small shops/offices, small hotels/guest houses); segregation of circuits; categories of circuit (band I and II circuits); proximity to non-electrical services

Increased risk of electrical shock areas: eg inside the main property (rooms containing a fixed bath or shower, sauna, swimming pool), equipment outside equipotential zone (shed, garage, workshop, garden, pond)

2 **Understand the methods used to protect circuits**

Types of overcurrent protection device: fuse eg rewireable, cartridge; miniature circuit breakers (MCBs); residual current breaker with overload protection (RCBO)

Circuit protection methods: earthing and bonding eg earthed equipotential bonding and disconnection of supply (EEBADS or EEBADOS), earthed neutral system, system classification (terra-terra (TT) and terra-neutral (TN) with combined (C) and separate (S) variations (TNC, TNS, TNC-S), earth electrodes, protective multiple earthing (PME), earth fault loop impedance, typical values; protective conductor circuit eg main and supplementary equipotential bonding conductors, earthing terminal; residual current devices (RCDs); other protection methods eg class 2 equipment, class 3 equipment; cable size eg from tables for current loading and thermal constraints; protection from mechanical damage eg armoured cable, cable trunking, cable tracking

3 **Be able to install and test lighting and power circuits**

Lighting and power circuits installations: use of flexible and non-flexible cable; use of tables to select cable type and size; circuit components (consumer unit/ circuit isolation device, light switching eg 1-gang, 2-gang, 1-way, 2-way, intermediate; power socket outlets eg ring, radial, switched fused spur connection units; other types of power circuits eg immersion heater, heated towel rail)

Circuit testing: for compliance with circuit diagram eg operation of switches, circuit continuity, polarity, insulation resistance checks

4 **Know the non-statutory and statutory regulations relating to the provision of an electrical installation**

Statutory regulations: scope, object, principles and use of relevant parts of statutory wiring, installation and site regulations eg Health and Safety at Work Act, Electricity Supply Regulations, Electricity at Work Regulations, the Building Regulations (particularly Part P), Construction (Design and Management) Regulations, Electricity Equipment Safety Regulations, Electromagnetic Compatibility Regulations

Non-statutory regulations: scope, object, principles and use of relevant sections of the wiring regulations eg BS7671: 2001 plus amendments and relevant guidance notes

Grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all of the learning outcomes for the unit. The criteria for a pass grade describes the level of achievement required to pass this unit.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 interpret two different lighting circuit diagrams, explain the function of the circuits and why the cables and protective devices have been chosen for each installation P2 interpret two different power circuit diagrams and explain the function of the circuits and why the cables and protective devices have been chosen P3 describe the extra considerations required for an electrical installation in an area of increased risk of electrical shock P4 explain the operation of the three types of overcurrent protective devices and describe a suitable electrical installation application for each	M1 carry out calculations to obtain cable sizes, given the power and voltage, taking installation methods and correction factors into account M2 inspect and test a given electrical installation for compliance with installation instructions and relevant regulations M3 explain and justify the steps taken to prevent electric shock by indirect contact.	D1 analyse the design specification of a domestic installation having at least six circuits, including the use of diversity when determining the final maximum demand current D2 explain and justify the inspection and testing methods carried out for a lighting and a power circuit.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P5 describe the function and application of two different circuit protection methods P6 install and test two different lighting circuits in accordance with current wiring regulations P7 install and test two different power circuits in accordance with current wiring regulations P8 describe the statutory and non-statutory regulations that apply to an electrical installation on the inside of a building P9 describe the statutory and non-statutory regulations that apply to an electrical installation on the outside of a building.		

Essential guidance for tutors

Delivery

This unit could be delivered as a stand-alone package or be integrated with other electrical units to produce a more holistic approach to electrical installations across a wide range of premises and applications.

The unit should be delivered using a balanced mix of practical and theory sessions. Encouraging learners to adopt an investigative approach will help link the practical work to the theory. This will help learners to understand why things are done in certain ways.

Lighting and power circuits offer a fundamental introduction to the understanding of electrical circuits. Their investigation can also provide knowledge of safety and relevant regulations, inspections of work done, checking to acceptable standards and wiring regulations. The lighting and power circuit installations can be delivered using junction box and/or loop-in methods. Work can be done on boards, but some fixing to walls should be considered as this will help to make the installation more realistic.

The over-current protective device is usually referred to as 'the fuse'. For this unit, learners must be aware of the advantages and disadvantages of rewireable and cartridge fuses, miniature circuit breakers (MCBs) and residual devices (RCDs and RCBOs, referred to in some texts as RCOBs but both meaning residual current devices that offer overload-current protection). Encouraging learners to carry out research can be an effective way of covering this area and there is plenty of information on these devices available on the internet, for example, the On-Site Guide (IEE, 2004, or later versions as they become available).

The installation of electrical circuits starts with the design process. Learners are expected to be able to determine cable sizes, which requires a relatively complex string of calculations involving design current, use of correction factors, assessment of thermal constraints and shock protection constraints. These are impossible without the use of algebra, shape, space and scale drawings, etc.

Additionally, learners must be able to make use of the operating characteristic curves (time/current graphs) for a range of protective devices. It is therefore essential that learners have completed or are undertaking *Unit 4*: *Mathematics for Technicians*, as this unit will provide these skills.

Over recent years, the Wiring Regulations have contained an expanding section about 'special installations or locations'. These refer to areas where there is an increased risk of electric shock, usually due to the likelihood of moisture being present. Addressing this topic could include the consideration of switching arrangements (type and position of device) for devices such as electric showers, bathroom lighting or heated towel rails. Learners could also consider the requirements to break the earth connection when taking a supply outside the equipotential zone of the main building to wire up a shed, effectively creating a local TT system. Tutors should mention the need to use non-conductive pipes to connect an outside water tap. This will encourage learners to appreciate the complex considerations needed when an artefact is provided for a specific purpose.

Few learners will have had prior experience in this area of work and so it will be essential to provide a formal introduction to the content. This introduction should emphasise the safety aspects of working with electricity and should make learners aware of the relevant statutory and non-statutory regulations. These aspects can be further developed as learners progress but, at the outset, it is important to make them aware of the hazards that they may encounter and the regulations that apply to electrical equipment and installation.

One approach to the delivery of this unit would be a series of practical investigations supplemented by appropriate theory. Investigations could be based on individual learning outcomes or could combine several. For example, an investigation of electrical protection devices could involve learners in selecting a protection device for a particular application. This would bring together elements from learning outcomes 1, 2 and 3.

In all cases, the approach used should take into account the needs of individual learners and the range of industries that centres are working with or preparing their learners for.

Where the learning outcomes are delivered sequentially, is important to stress the inter-relationship that exists between them. For example, the choice of a suitable cable for a particular application for learning outcome 1 needs to be linked to the selection of cable type and size in learning outcome 3 and vice versa.

Tutors should always ensure that each learner has the correct personal protective equipment and that systems are safe for inspection and operation. It is also important that learners work in a safe manner and are suitably supervised when using equipment or working on systems.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Assessment

P1 requires learners to demonstrate their ability to interpret two different lighting circuit diagrams, explain the function of each circuit and say why the cables and protective devices have been chosen for each of the installations.

P2 is similar but focuses on power circuit diagrams. In order to satisfy the cable calculation requirements of P1 and P2, learners should be able to perform calculations based on design current. However, to satisfy M1, learners should take into account appropriate correction factors, use tabulated cable ratings and work with voltage drops.

For P3 learners could use diagrams/sketches to help describe a relevant installation inside a property or equipment outside the equipotential zone. This should include the positioning of equipment and any other safety features and reference to appropriate regulations.

For P4 learners must explain the operation of all three types of overcurrent protective device listed in the unit content (fuse, miniature circuit breaker, residual current breaker with overload protection). They will then need to describe a suitable electrical installation application for each device.

For P5, learners need to describe the function and application of two different circuit protection methods (eg earthing and bonding, protective conductor circuit, residual current devices) or any other protection methods (eg class 2 equipment, class 3 equipment). Learners must refer to issues of cable size (eg from tables for current loading and thermal constraints) and the method used to protect the circuit from mechanical damage (eg armoured cable, cable trunking, cable tracking).

P6 and P7 require learners install and test two different lighting circuits and two different power circuits in accordance with current wiring regulations. One approach to assessment might be to use these four circuits as the focus for the assessment of all the other criteria. This type of approach to assessment would provide maximum coherence but, by necessity, would fragment the criteria. Therefore centres would need to take care when tracking learner achievement.

Records for each installation would need to be planned carefully to indicate learners have met the relevant criteria and unit content and only when all four installations have been completed satisfactorily would each criterion be fully achieved.

Evidence for this work could be a mix of tutor observation records, annotated photographic evidence, the learner's research and preparation notes and formal reporting. For example, in addition to the installation, a formal written description of the extra considerations required for an electrical installation in an area of increased risk of electrical shock would be required. The evidence could be brought together as a portfolio record for each installation. The constraint to this approach would of course be the centre's ability to provide sufficient installation facilities to cope with a reasonable group size.

For P8 and P9 descriptions of the statutory and non-statutory regulations that apply to an electrical installation on the inside and outside of a building could also be planned to fit into the above assessment approach. Learners will need to summarise the relevant legislation (statutory and non-statutory) that needs to be considered when electrical installation work is carried out in and around buildings. The list given in the unit content should not be seen as exhaustive and centres should ensure that the most current, relevant and up-to-date legislation is covered.

Less integrated approaches could also be used to good effect where equipment or other constraints apply. However, a circuit should only be deemed to be correctly wired when any single cores of conductors with diameters less than 2.5mm^2 are terminated into a screwed terminal. Other elements of good practice also need to be demonstrated, all connections must abide by the latest UK/EU colour code standards (or equivalent for other countries), and the circuit must work.

M1 and D1 build on learners' understanding from P1 an P2. For the application of diversity in D1, the circuits could include examples such as upstairs and downstairs ring circuits, upstairs and downstairs lighting circuits, cooker (with or without 13A socket), immersion heater, or outside supply to a garage/shed.

Having carried out the installations for P6 and P7, the learner should be expected, as simply a matter of good practice, to check their own work for compliance ahead of assessment. This can be extended to meet M2, where learners inspect others' work.

In doing this, learners should follow relevant inspection and test procedures using appropriately annotated inspection and testing documentation (such as those illustrated in the Wiring Regulations or the On-Site Guide or other centre devised certification). The activity for this could be the supervised assessment of the work carried out by a fellow learner who is presenting their installation as evidence for P6 and P7.

M3 builds on the work carried out for P3, P4 and P5. This will include earthing connections and other means, such as class II and class III systems. To differentiate the work at merit from that at pass, it is expected that at this level learners not only know what needs to be done but can explain and justify the actions taken. This should include why supplementary bonding may need to be applied, why an RCD is needed outside the equipotential zone, and how it operates, why it needs to operate in a certain specified time and the relevance of its current sensitivity ($I_{\Delta n}$) to the effects of electricity passing through a human body or livestock.

D2 builds on the inspection work undertaken for M2. Learners are required to explain and justify the inspection and testing methods carried out for one lighting and one power circuit. This should take into account the what, where and how of the inspection process and should give learners an opportunity to demonstrate their understanding of the unit as a whole.

The evidence, which is likely to be a technical report, should clearly explain what they were doing during the inspection and why. It should also include what they were looking for and why; which test equipment they used, how and why it was 'proved' before and after use and, finally, how well the results show the installations comply with the respective circuit diagrams.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit covers underpinning knowledge associated with the SEMTA Level 3 National Occupational Standards in Electrical and Electronic Servicing, particularly:

- Unit 12: Diagnosing and Analysing Faults in Domestic Appliance Equipment
- Unit 14: Rectifying Faults in Domestic Appliance Equipment.

The unit can be linked to *Unit 5*: *Electrical and Electronic Principles* and *Unit 52*: *Electrical Technology*.

Essential resources

Centres will need to provide access to suitably equipped workshops for the installation of electrical circuits (preferably with some installation onto walls or, where necessary boards), together with relevant test equipment to carry out tests to prescribed regulations (eg BS7671 and Guidance Note 3).

Learners will also require access to a range of wiring diagrams, test rigs and wiring boards, electrical tools and components and cabling required for lighting and power installations.

Centres will need to provide appropriate documentation such as statutory and non-statutory regulations, manufacturers' catalogues, data sheets and relevant cable, component and equipment specifications.

Indicative reading for learners

Textbooks

Hinsley A — *Testing Electrical Installations*: *A Practical Guide for Electricians*, (Castleknight Publications, 2005) ISBN 2952413835

Scaddan B G — *IEE Wiring Regulations Explained and Illustrated*: *A Practical Guide to BS7671*:*2001* (Newnes, 2001) ISBN 0750654686

Whitfield J — *The Electrician's Guide to the 16th Edition of the IEE Wiring Regulations* (EPA Press, 2005) ISBN 0953788547

Other publications

BS 7671: *2001(2004) Requirements for Electrical Installations* (IEE, 2004)

IEE Guidance Note 3 — Inspection and Testing, *4th Edition* (IET, 2002)

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Tutors should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Application of number Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• describing domestic circuit arrangements (floor area for ring circuit) and using scale plans of typical installations • calculating cable sizes and voltage drops and interpreting fuse characteristic graphs • comparing domestic installations for socket and lighting numbers and power ratings of appliances.	N3.1 Plan an activity and get relevant information from relevant sources. N3.2 Use this information to carry out multi-stage calculations to do with: a amounts or sizes b scales or proportions c handling statistics d using formulae. N3.3 Interpret the results of your calculations, present your findings and justify your methods.
Communication Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• researching installation methods, correction factors and earthing requirements • summarising the requirements of relevant legislation • researching and reporting on protective devices.	C3.2 Read and synthesise information from at least **two** documents about the same subject. Each document must be a minimum of 1000 words long. C3.3 Write **two** different types of documents each one giving different information about complex subjects. One document must be at least 1000 words long.

Information and communication technology Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• researching types of fuse and MCB • using software to present information on circuit installations and explaining the operation of types of overcurrent protective devices • using spreadsheets to help with calculations.	ICT3.1 Search for information, using different sources, and multiple search criteria in at least one case. ICT3.2 Enter and develop the information and derive new information. ICT3.3 Present combined information such as text with image, text with number, image with number.
Problem solving Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• planning for the installation of lighting and power circuits • installing and testing lighting and power circuits in accordance with current wiring regulations.	PS3.1 Explore a problem and identify different ways of tackling it. PS3.2 Plan and implement at least one way of solving the problem. PS3.3 Check if the problem has been solved and review your approach to problem solving.