Unit 40: Electrical Installation Standards and Components in Building Services Engineering

Unit code: H/600/0408

QCF Level 3: BTEC Nationals

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to give learners a knowledge of legal requirements and standards relevant to electrical installations, and different wiring techniques. It also provides learners with an understanding of earthing and bonding principles and the need for final circuits and circuit protection when designing electrical services installations.

Unit introduction

Building services engineers need to understand the legal requirements and standards that apply to the design of electrical services installations. They also need to understand the operational principles and features of the various components, materials and techniques used within typical electrical services in buildings.

This unit explores the Institution of Engineering and Technology British Regulations document BS7671 (Requirements for Electrical Installations). Its relationship with statutory regulations is investigated, as is the assessment of the general characteristics associated with electrical installations.

This unit should preferably be undertaken after learners have achieved a basic understanding of the principles of electrical science.

Learning outcomes

On completion of this unit a learner should:

1 Know the regulations and legislation applicable to electrical installations

2 Know the different wiring techniques used in electrical installations

3 Understand earthing and bonding principles

4 Understand the need for final circuits and circuit protection

5 Understand the requirements for special installations.

Unit content

1 Know the regulations and legislation applicable to electrical installations

Regulations: Institution of Electrical Engineers (IEE) Wiring Regulations; scope and objective; fundamental principles for safety; assessment of purposes; supplies and structure, external influences, compatibility and maintainability

Legislation: Electricity Supply Quality Continuity Regulations; Health and Safety at Work Act 1974; Electricity at Work Regulations 1989; Building Regulations; CDM Regulations; Electricity Equipment Safety Regulations 1994; The Electromagnetic Compatibility Regulations 1992

2 Know the different wiring techniques used in electrical installation

Wiring techniques: containment; segregation of circuits; non-flexible low voltage cables; flexible cords, extra low and low voltage cables for power, data and security; switching

Containment: features; materials; standard sizes; assembly and installation procedures; capacity; comparative costs and benefits of various ducts, bus-bar, conduit and trunking, basket, ladder rack, uni-strut systems; criteria for selection

Segregation of circuits: categories of circuits

Non-flexible low voltage cables: details of construction; features and materials; advantages and disadvantages; support; protection; jointing and termination; cross-linked polyethylene (XLPE); low smoke and fumes (LSF); identification of fixed wiring

Flexible cords, extra low and low voltage cables for power, data and security: details of their construction; features and materials used including fibre optic cables; advantages and disadvantages; use and levels of insulation for extra low and low voltage power; audio and high frequency applications

Switching: switch position; functional switching; switching off for mechanical maintenance; emergency switching and isolation; modular wiring techniques

3 Understand earthing and bonding principles

Earthing and bonding principles: protection against electric shock; principles of earthing; protective conductors; other protection methods; residual current devices

Protection against electric shock: nature of electric shock; resistance of electric shock; basic protection and fault protection; protection for users of exterior equipment

Principles of earthing: advantages, disadvantages; system classification; fault loop; earth electrodes; protective multiple earthing (PME); impedance values

Protective conductors: earthing; bonding; main equipotential; supplementary; types; sizes; calculations associated with protective conductors

Other protection methods: class 2 equipment; non-conducting locations; earth-free local equipotential bonding; electrical separation

Residual current devices: principle of operation; use and limitations

4 Understand the need for final circuits and circuit protection

Final circuits: types eg fused plug, socket outlet, ring circuit, radial and tree circuits, industrial socket outlets, lighting, cooker, off-peak; final circuit arrangements; application of diversity; maximum demand

Circuit protection: against thermal effects, burns and fire; against overcurrent and short circuits; characteristics and limitations of devices such as fuses and circuit breakers

5 Understand the requirements for special installations

Special installations: regulations; standard installations; other installations

Regulations: BS7671:2008 – IEE Regulations Requirements for Installations or locations (Part 7)

Standard installations: locations containing a bath or shower; swimming pools and other basins; rooms and cabins containing sauna heaters; construction and demolition site installations; agricultural and horticultural premises; conducting locations with restricted movement; electrical installations in caravan/camping parks and similar locations; marinas and similar locations; solar photovoltaic power supply systems; mobile or transportable units; floor and ceiling heating systems

Other installations: highway supplies and street furniture; heating appliances and their installation; electrode boilers; instantaneous water heaters; high voltage discharge lighting; reduced voltage systems

Assessment and grading criteria

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

Assessment and 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 describe the main regulations and legislation relating to electrical installations [IE2, IE4, IE6, SM2, SM3, SM4]	**M1** perform calculations to specify protective conductor sizes	**D1** evaluate electrical installations in a given building in terms of compliance with relevant legislation and regulations
P2 describe the operational features, characteristics and applications of cables and cords [IE2, IE4, IE6, SM2, SM3, SM4]		
P3 describe the operational features, characteristics and applications of containment methods [IE2, IE4, IE6, SM2, SM3, SM4]		
P4 describe the operational features, characteristics and applications of installation methods [IE2, IE4, IE6, SM2, SM3, SM4]		
P5 explain the requirements, operational features, characteristics and applications of electrical earth and shock protection [IE2, IE4, IE6, SM2, SM3, SM4]	**M2** evaluate protective conductor, earthing and bonding designs for a given building in terms of compliance with regulations and legislation	

Assessment and 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:**
P6 explain the operational features, characteristics and applications of residual current devices [IE2, IE4, IE6, SM2, SM3, SM4]	**M3** propose solutions to problems relating to the specification of final circuits	**D2** justify different types of overcurrent and short-circuit protective devices used in electrical installation in terms of cost and performance-in-use.
P7 discuss the use of final circuits [IE2, IE4, IE6, SM2, SM3, SM4]		
P8 apply the principles of diversity to final circuits [IE2, IE4, IE6, SM2, SM3, SM4]		
P9 explain the principle and applications of overcurrent and short-circuit protection devices [IE2, IE4, IE6, SM2, SM3, SM4]		
P10 explain the application of regulations in locations containing baths, showers and electric floor heating systems. [IE2, IE4, IE6, SM2, SM3, SM4]	**M4** compare the requirements of two special electrical installations other than those relating to baths, showers and electric floor heating systems.	

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Tutors delivering this unit have opportunities to use a wide range of techniques. Lectures, discussions, seminar presentations, site visits, supervised practicals, research using the internet and/or library resources and use of personal and/or industrial experience are all suitable. Delivery should stimulate, motivate, educate and enthuse learners. Visiting expert speakers could add to the relevance of the subject.

Some learners following this unit will be working with, or have experience of, electrical installations within building services. The tutor will need to encourage learners with little knowledge of the Institution of Electrical Engineers Wiring Regulations to undertake a considerable amount of self-study. Individual tutorial support will be a key factor in the delivery of this unit.

This unit could be delivered as stand alone but could also be integrated with other electrical services units to produce a more holistic approach to building services.

The method of delivery should, as far as possible, be activity based. Learning activities could include the use of case studies, site visits and product investigations.

This unit focuses on linking principles with practical applications. This implies that learners will have a basic understanding of science and analytical methods before starting this unit. Even if learners do not have such knowledge and understanding on entry, there will be no delivery and/or assessment issues if the relevant core units are delivered early in the programme.

Group activities are permissible, but tutors will need to ensure that individual have equal experiential and assessment opportunities.

Health, safety and welfare issues are paramount and should be reinforced through close supervision of all workshops and activity areas, and risk assessments must be undertaken before practical activities are taken. Centres are advised to read the *Delivery approach* section in the specification, and *Annexe H: Provision and Use of Work Equipment Regulations 1998 (PUWER).*

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction to the unit
Whole-class teaching: BS7671 Regulations scope and objectives, fundamental principles for safety, relationship with statutory regulations, assessment of supply Small group work: one topic per group of general characteristics, purposes, supplies and structure, external influences, compatibility, maintainability of electrical installations Short presentation by each group to whole-class, supported by handout. Tutor to guide, amend and collate as necessary
Whole-class teaching: types of containment, features, materials, standard sizes, assembly and installation procedures, capacity Individual learner research into comparative costs and benefits of various, ducts, bus-bar, conduit and trunking, basket, ladder rack and unistrut systems; criteria for selection Whole-class teaching: non-flexible low voltage cables, details of construction, features and materials, advantages, disadvantages, support, protection, jointing and termination, cross-linked polyethylene (XLPE), low smoke and fumes (LSF), identification of fixed wiring, segregation of circuit categories Whole-class teaching: flexible cords, extra low and low voltage cables for power, data and security including fibreoptic cables, details of their construction Individual learner research into features and materials used, advantages, disadvantages, use and levels of insulation for extra low and low voltage power, audio and high frequency applications Whole-class teaching: switching requirements, switch position, functional switching, switching off for mechanical maintenance, emergency switching and isolation, modular wiring techniques
Whole-class teaching: protection against electric shock, nature of electric shock, resistance of electric shock, basic and fault protection, protection for users of exterior equipment, other protection methods, class 2 equipment, non-conducting locations, earth-free local equipotential bonding, electrical separation Whole-class teaching: principles of earthing, advantages, disadvantages, system classification, fault loop, earth electrodes, protective multiple earthing (PME), impedance values, protective conductors, earthing, bonding, main equipotential, supplementary Small-group work: one topic per group of types, sizes, calculations associated with protective conductors, residual current devices, principle of operation, use and limitations Short presentation by each group to whole-class, supported by handout. Tutor to guide, amend and collate as necessary
Assignment 1: Legislation, Wiring Techniques and Earthing and Bonding Principles
Whole-class teaching: circuits, fused plug, socket outlet, ring circuit, radial and tree circuits, industrial socket outlets, lighting, cooker, off-peak, final circuit arrangements, application of diversity, protection against thermal effects from burns and fire Individual learner research: over current protection, characteristics and limitations of devices such as fuses and circuit breakers

Topic and suggested assignments/activities and/assessment
Whole-class teaching: BS7671:2008 – IEE Regulations Requirements for Installations or Locations listed in Part 7 – locations containing a bath or shower, swimming pools and other basins, rooms and cabins containing sauna heaters, construction and demolition site installations, agricultural and horticultural premises, conducting locations with restricted movement, electrical installations in caravan/camping parks and similar locations, marinas and similar locations, solar photovoltaic power supply systems, mobile or transportable units, floor and ceiling heating systems
Individual research: other installations, highway supplies and street furniture, heating appliances and their installation, electrode boilers, instantaneous water heaters, high voltage discharge lighting, reduced voltage systems, electric fences, petrol filling stations, underground car parks
Assignment 2: Final Circuits, Circuit Protection and Special Installations
Review of unit and assignment feedback

Assessment

Evidence for this unit may be gathered from a variety of sources, including well-planned investigative assignments, case studies or reports of practical assignments. There are many suitable forms of assessment that could be used, and tutors are encouraged to consider and adopt these where appropriate. Some example assessment approaches are suggested below. However, these are not intended to be prescriptive or restrictive, and are provided as an illustration of the alternative forms of assessment evidence that would be acceptable. Some criteria can be assessed directly by the tutor during practical activities. If this approach is used then suitable evidence would be observation records or witness statements.

The unit has been written to allow all assessment evidence to be produced from two well-designed projects based around electrical installations for a real building. The building(s) selected should have a wide variety of uses, functions, activities and features. This will give learners the opportunity to consider options and make decisions. It is equally important that any selected buildings are not too complex and should be capable of realistically incorporating conventional final circuits, motors, drives and other items of fixed plant.

Learners should be given a range of architectural drawings for them to extract the required information. These could be some or all of plans, elevations, sections and/or details. Where centres intend to use buildings of their own design, the buildings must meet current building design standards and should contain the same information as would be present in professionally produced architectural drawings.

Although this unit functions effectively as a stand-alone unit, it is strongly recommended that, where learners are studying other units concurrently, assessment evidence is coordinated to avoid unnecessary duplication. In these situations centres may wish to consider the use of integrative assignments. For example, assessments associated with electrical design, inspection testing and

Commissioning, control applications and so forth can be integrated within the two assessment instruments designed to meet the grading criteria for this unit.

The first assignment should cover P1, P2, P3, P4, P5, M1, M2 and D1 and the second assignment should cover P6, P7, P8, P9, P10, M3, M4 and D2. Both assignments can be completed and assessed in stages, if this helps learners.

To achieve a pass grade learners must meet the 10 pass criteria listed in the grading criteria grid.

For P1, learners must describe the regulations and legislation relating to electrical installations. Although statutory legislation should provide the main focus there must also be evidence of understanding the importance of BS7671 and the IEE 17th Wiring Regulations.

For P2, learners must describe the operational features, characteristics and applications of common cables and cords. These should include single-core and multi-core 70°C thermoplastic, 90°C thermosetting, armoured and non-armoured, cables clipped direct, in conduit, trunking, on tray and in basket. Learners do not need to recommend particular strategies for specific applications, but they are expected to contextualise their descriptions by indicating typical applications and criteria which might influence their selection.

For P3, learners must describe the operational features, characteristics and applications of containment methods. The description should include technical issues and comparative costs and the general criteria used to select appropriate methods for given situations.

For P4, learners must describe the operational features, characteristics and applications of installation methods. The evidence should build on that for P2 and P3.

For P5, learners must explain the requirements, operational features, characteristics and application of electrical earth and shock protection techniques and installations. They are expected to describe the properties, features and characteristics of the items listed and relate these to their selection and application.

For P6, learners must explain the operational features, characteristics and application of residual current devices. This should supplement the evidence provided for P5 by concentrating on supplementary protection against shock.

For P7, learners must discuss the use of the various types of final circuit within buildings. The types of final circuit to be included are listed in the unit content for learning outcome 4. Evidence could be in the form of a written report.

For P8, learners must apply the principles of diversity to final circuits. This should involve the techniques used to determine diversity and maximum demand. There should be evidence that learners understand the procedures used.

For P9, learners must explain the principle and applications of common overcurrent and short-circuit protection devices. Learners do not need to recommend particular strategies for specific applications, but they are expected to contextualise their descriptions by indicating typical applications and criteria which might influence their selection.

For P10, learners must explain the application of regulations in locations containing baths, showers and electric floor heating systems. There is no requirement to refer to special installations other than the three specified above. How the technical aspects of the special installations ensure compliance with the appropriate regulations must however be clear.

To achieve a merit grade learners must meet all of the pass grade criteria and the four merit grade criteria.

For M1, learners must produce clear and accurate answers to problems relating to the specification and sizing of protective conductors. This should include live and protective conductors, and refer to cable size. Learners are expected to extract and present the necessary data from these calculations.

For M2, learners must evaluate protective conductor, earthing and bonding designs for a given building in terms of compliance with regulations and legislation. Evidence should demonstrate a clear understanding of why such protection is necessary, how it is achieved and how this ensures compliance. This could be a natural extension of the work carried out in P5.

For M3, learners must produce clear and accurate answers to problems relating to the specification of final circuits. This should include the heat loads of each section, including the effect of pipework. This could be a natural extension of the work carried out in P6 and P7.

For M4, learners must compare the requirements of two special electrical installations other than those relating to baths, showers and electric floor heating. This could be a natural extension of the work carried out in P9.

To achieve a distinction grade learners must meet all of the pass and merit grade criteria and the two distinction grade criteria.

For D1, learners must evaluate electrical installations in terms of compliance with relevant legislation and regulations.

For D2, learners must justify different types of overcurrent and short-circuit protective devices used in electrical installation in terms of cost and performance in use. This should build upon the evidence produced for P9 and M4.

Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4, P5, M1, M2, D1	Legislation, Wiring Techniques and Earthing and Bonding Principles	As an electrical installation training advisor, you have been asked to provide a training manual to be used by trainee building services engineers. This comes in two parts and should be used to link legislation and practical installations. Exemplar calculations should be included throughout.	Report, accompanied by sketches, drawings, graphs, charts, tables, specifications, calculations and text as appropriate.
P6, P7, P8, P9, P10, M3, M4, D2	Final Circuits, Circuit Protection and Special Installations	As above but for final circuits, circuit protection and special installations.	Report, accompanied by sketches, drawings, graphs, charts, tables, specifications, calculations and text as appropriate.

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

This unit forms part of the BTEC Construction and the Built Environment sector suite. This unit has particular links with the following unit titles in the Construction and the Built Environment suite:

Level 1	Level 2	Level 3
		Electrical Principles in Building Services Engineering
		Electrical Installation Design in Building Services Engineering

The learning outcomes in this unit provide a sound basis for the study of similar units at Higher National and degree level.

This unit links to the Edexcel Level 3 NVQ in Technical Design (Construction Environment).

There are also links with Summit Skills N/SVQ Level 3 Building Services Engineering Technology and Project Management. In particular with:

- Unit SST/NOS 3: Apply Design Principles to Building Services Engineering Projects
- Unit SST/NOS 7: Provide Technical and Functional Information to Relevant People.

Also of relevance is Summit Skills N/SVQ Level 4 Building Services Engineering Technology and Project Management In particular with:

- Unit SSTE/NOS 7: Prepare and Advise on Building Services Engineering Project Design Recommendations
- Unit SSTE/NOS 8: Prepare and Agree Detailed Building Services Engineering Project Designs.

Essential resources

Learners will need access to a wide range of publications, reference data, manufacturers' products/information and computer facilities. The centre should work closely with building services contractors, architects and manufacturers in order to provide realism and relevance to the project work.

Employer engagement and vocational contexts

Support to enable centres to initiate and establish links to industry, and to networks arranging visits to industry and from property practitioners is given below:

- Learning and Skills Network – www.vocationallearning.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Summit Skills – www.summitskills.org.uk
- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI University of Warwick) – www.warwick.ac.uk/wie/cei/

Indicative reading for learners

Textbooks

ConstructionSkills – *IEE Regulations Study Notes: BS 7671 – Requirements for Electrical Installation, 17th Edition* (ConstructionSkills, 2008) ISBN 1857512786

Institution of Electrical Engineers – *Requirements for Electrical Installations: IEE Wiring Regulations, 17th Edition: BS7671* (IEE, 2008) ISBN 0863418449

Scaddan B – *17th Edition IEE Wiring Regulations: Explained and Illustrated, 8th Edition* (Newnes, 2008) ISBN 9780750687201

Whitfield J – *The Electrician's Guide to the 17th Edition of the IEE Wiring Regulations, 1st Edition* (EPA Press, 2008) ISBN 0953788555

Journals

Electrical and Mechanical Contractor – Electrical Contractors' Association

Professional Electrician and Installer – Hamerville Magazines Ltd

Websites

www.elecsa.org.uk	Electrical Contractors' Association
www.enginuity.org.uk	Engineering resources
www.jib.org.uk	Joint Industry Board for the Electrical Contracting Industry
www.jtltraining.com	Training in the electrical sector
www.scenta.co.uk	Engineering and technology careers and news
www.sectt.org.uk	Scottish Electrical Charitable Training Trust
www.semta.org.uk	Sector Skills Council for Science, Engineering and Manufacturing Technologies
www.summitskills.org.uk	Sector Skills Council for the Building Services Engineering Sector

Delivery of personal, learning and thinking skills (PLTS)

The following table identifies the PLTS that have been included within the assessment criteria of this unit:

Skill	When learners are ...
Independent enquirers	planning and carrying out research, appreciating the consequences of decisions, analysing and evaluating information, judging its relevance and value and supporting conclusions using reasoned arguments and evidence, as they: • describe the legislation relating to electrical installations • describe the operational features, characteristics and applications of cables and cords • describe the operational features, characteristics and applications of containment methods • describe the operational features, characteristics and applications of installation methods • explain the requirements, operational features, characteristics and applications of electrical earth and shock protection • explain the operational features, characteristics and application of residual current devices • discuss the use of final circuits and apply diversity principles • explain the principles and applications of overcurrent and short-circuit protective devices • explain the applications of regulations in locations containing baths, showers and electric floor heating systems
Self-managers	working towards goals, showing initiative, commitment and perseverance, organising time and resources, prioritising actions and anticipating, taking and managing risks, as they: • describe the legislation relating to electrical installations • describe the operational features, characteristics and applications of cables and cords • describe the operational features, characteristics and applications of containment methods • describe the operational features, characteristics and applications of installation methods • explain the requirements, operational features, characteristics and applications of electrical earth and shock protection • explain the operational features, characteristics and application of residual current devices • discuss the use of final circuits and apply diversity principles • explain the principles and applications of overcurrent and short-circuit protective devices • explain the applications of regulations in locations containing baths, showers and electric floor heating systems

Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using the internet to research electrical installation saving material electronically using email to communicate with the tutor and other learners
Manage information storage to enable efficient retrieval	downloading and saving internet files and their own work electronically
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	using the internet to research electrical installation saving material electronically, using email to communicate with the tutor and other learners
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including:	producing reports, manuals and/or presentations for both formative and summative assessment purposes
Present information in ways that are fit for purpose and audience	
Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists	using email to communicate with the tutor and other learners
Mathematics	
Identify the situation or problem and the mathematical methods needed to tackle it	performing calculations relating to electrical installations
Select and apply a range of skills to find solutions	
Draw conclusions and provide mathematical justifications	
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching electrical installation principles and practices from books, journals, CD ROMs and websites
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	producing reports for assessment purposes.