Unit 41: Electrical Installation Design in Building Services Engineering

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

Every building project includes two key phases. The first of these is concerned primarily with the design and construction of the 'shell' of the building — the floors, walls and roof. In the second phase, the shell is turned into a habitable building by building services engineers, who design, manage and install: the electrical and communication services, the heating, ventilating and air conditioning, the public health and the fire protection installations etc.

Building services engineers need to have an understanding of the industry standards applicable to electrical services installations. They also need to understand the principles and processes used to design the electrical services in buildings. The aim of this unit is to provide learners with that understanding.

The focus of the unit is on linking principles with practical applications. Learners should therefore have achieved a basic understanding of electrical installation standards and equipment together with science and analytical methods, or at least have started studying these, before undertaking it.

Learning outcomes

On completion of this unit a learner should:

1 Know how to establish the electrical and lighting requirements for buildings and select design conditions

2 Be able to design electrical and lighting installations for specific applications

3 Know the requirements for data distribution, security and fire protection

4 Understand the requirements for special and hazardous locations

5 Know the requirements for inspection, testing and certification of electrical installations.

Unit content

1 **Know how to establish the electrical and lighting requirements for buildings and select design conditions**

Design specification: establishing requirements and specification for lighting, small power, data, fire alarm installations for domestic, commercial, industrial and public sector applications; client, user and environmental requirements and considerations; locations with special requirements

Design information: identification of relevant standards and legislation

Lighting: standard units; illumination levels; relationship to tasks; glare rating; inverse square law of illumination; cosine law of illumination

2 **Be able to design electrical and lighting installations for specific applications**

Lamps and luminaires: operational features and characteristics of lamps; efficacy, stroboscopic effect and re-strike time; operational features and characteristics of luminaires; classification; output ratios, ingress protection; photometric performance; selection of lamps and luminaries for particular applications

Design of lighting installations and their circuits: lumen calculation for number of luminaires for artificial light installations; spacing ratios; glare assessment and prevention

Electrical installation design: identification of small power requirement; number and location of socket outlets and other small power loads; identification of mechanical plant loads; zoning of lighting and small power loads; cable routing, distribution; location of distribution boards and equipment; switching arrangements; maximum demand; diversity

Drawings: layout, schematic, detail, graphical symbols; db/equipment schedules

Short circuit and overload protection: prospective short-circuit current (PSC); operating time; backup protection; short circuit; over current and combined protection, discrimination

Current carrying capacity: method of installation; operating temperatures; correction factors for ambient temperature, grouping; thermal insulation, semi-enclosed fusing; combination of grouping factors; cable sizing; determination of cable rating and voltage drop for short circuit and overload protection

3 **Know the requirements for data distribution, security and fire protection**

Distribution for data: horizontal and vertical distribution; structured cables for communication; clean and dirty earths; earth loops; category 5 and 6 installations; cable types

Security: types of detectors and their application; open and closed circuits

Fire protection: legislation and British Standards; levels of protection; types of automatic detectors and their operation; choice of detectors; manual call points; suitability of cables; stand-alone smoke detectors

4 **Understand the requirements for special and hazardous locations**

Wiring system and equipment required for: caravan sites; agricultural and horticultural installations; electric fences; controllers and earthing; petrol filling stations; underground car parks and dusty environments

Construction sites: legislation; electrical distribution

5 **Know the requirements for inspection, testing and certification of electrical installations**

Regulations: sequence of tests; initial verification; periodic inspection; frequency; information required by tester; expected values of results; supporting paperwork

Application: equipment employed, methods of testing

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 identify the requirements for small power, lighting, data and fire detection installations for specific applications; identify relevant standards and select design conditions where appropriate	M1 make comparisons between alternative lamps, luminaires, and switching arrangements and make valid and appropriate recommendations for specific applications	D1 analyse and justify the design rationale used in the production of a lighting and power design; demonstrate how the proposed design meets the needs of the client and their building
P2 describe how the features and characteristics of lamps and luminaires contribute to their selection for specific applications	M2 produce comprehensive designs for lighting, small power, data and fire alarm installations	D2 analyse and justify the design parameters and rationale used in the sizing and specification of low voltage power cables, small power equipment and fixed plant.
P3 describe the requirements of the IEE Wiring Regulations in relation to current-carrying capacity of cables and protection against electric shock, high temperatures, over current and short circuit	M3 produce clear and accurate answers to the calculations required to size low voltage power and lighting cables	

continued…

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:**
P4 describe the wiring systems, equipment and requirements of relevant standards and legislation in relation to external electrical installations including construction sites P5 identify the operational characteristics and applications of common data distribution fire and security equipment, cables and network distribution systems P6 produce functional installation layout designs and component lists for lighting, small power, data, fire alarms and security P7 describe the methods, instrumentation, documentation and legislative requirements appropriate to inspection and testing of electrical installations.	M4 analyse installation drawings, design calculations and manufacturer's data to produce detailed specifications, schedules and data for lighting, power, data and fire alarm equipment.	

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 the 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.

It is assumed that learners embarking on 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 IEE Wiring Regulations to undertake a considerable amount of self-study. Individual tutorial support will be a key factor.

This unit can be delivered as a stand-alone package, 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, product investigations and design exercises. The unit should not be perceived as an academic exercise and should at all times be based on real-life applications and reflect industry best practice.

Reference should be made to appropriate regulations, standard guides and sources of reference wherever necessary. Learners should be encouraged to use these documents to make informed decisions relating to the design of the various installations and help them understand the consequences of their decisions.

The use of manufacturers' current product information is also encouraged to help learners apply principles and procedures to real-life situations. This does not imply that the mechanistic use of manufacturers' data, with little consequent need for understanding, is always acceptable. The same logic applies to the use of specialist lighting and electrical design software and spreadsheets. Their use is encouraged but only after an understanding of the underlying principles required for manual calculations have been established.

The focus of this unit is on linking principles with practical applications and this implies that learners will have achieved an understanding of the components and materials used in electrical installations, together with basic science and analytical methods, before starting this unit. Even if learners do not possess 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 learners are provided with equal experiential and assessment opportunities.

Health, safety and welfare issues are paramount and should be strictly reinforced through close supervision of all workshops and activity areas, and risk assessments must be undertaken prior to practical activities. Centres are advised to read the *Delivery approach* section on page 24, and *Annexe G: Provision and Use of Work Equipment Regulations 1998 (PUWER)*.

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 employed and tutors are encouraged to consider and adopt these where appropriate. Some examples of possible 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. General guidance on the design of suitable assignments is available on page 19 of this specification.

Some criteria can be assessed directly by the tutor during practical activities. If this format is used then suitable evidence would be observation records or witness statements. Guidance on their use is provided on the Edexcel website.

The unit has been written to allow all the assessment evidence for all learning outcomes to be produced from a single well-designed project based around electrical installations for a real building. The building(s) selected for the purpose of assessment should have a wide variety of uses, functions, activities and features. This will allow learners the opportunity to consider options and make decisions. It is important that any buildings selected are not too complex; they should be capable of realistically incorporating conventional final circuits, data, fire and security installations.

Learners should be provided with a range of architectural drawings for them to extract the required information. These could be some or all 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, the assessment evidence is coordinated to avoid unnecessary duplication. In these situations centres may wish to consider the use of integrative assignments. For example, assessment criteria associated with electrical components, inspection testing and commissioning etc can be integrated within an assessment instrument designed to meet the grading criteria for this unit.

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

For P1, learners must identify the requirements for small power, lighting, data and fire detection installations for specific applications; identify relevant standards and select design conditions where appropriate. For electrical installations they should recognise those locations which are likely to require an above or below average number of socket outlets and why. They should also recognise locations that are

likely to have fixed equipment; locations with plant likely to require 3 phase supply (or extra low voltage); locations which impose a higher risk or hazardous environment.

For data and fire detection, learners should identify those areas of a building which require special consideration and why. For lighting learners must be able to relate the probable tasks and activities within a location with appropriate lighting levels. For areas needing artificial lighting, learners should select appropriate lighting levels and glare rating. In each case, learners must support their selections by indicating all the sources of reference used and all the factors used in their selection.

Evidence for P1 must extend beyond the mechanistic use of standard tables. The buildings specified for the assessment must contain locations where a degree of judgement is required of the learner.

For P2, learners must describe how the features and characteristics of lamps and luminaires contribute to their selection for specific applications.

For P3, learners must describe the requirements of the IEE Wiring Regulations in relation to current-carrying capacity of cables and protection against electric shock, high temperatures, over current and short circuit.

For P4, learners must describe the wiring systems, equipment and requirements of relevant standards and legislation in relation to external electrical installations including construction sites.

For P5, learners must identify the operational characteristics and applications of common data distribution fire and security equipment, cables and network distribution systems.

For P6, learners must produce functional installation layout designs and component lists for lighting, small power, data, fire alarms and security.

For P7, learners must describe the methods, instrumentation, documentation and legislative requirements appropriate to inspection and testing of electrical installations. Evidence could be through the completion by learners of relevant testing and commissioning documentation completed by learners for specified systems.

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

For M1, learners must make comparisons between alternative lamps, luminaires, and switching arrangements and make valid and appropriate recommendations for specific applications. Learners should relate their decisions to the needs of particular clients and buildings and must outline any constraints and environmental considerations. This is a natural extension of the work carried out for P1 and P2.

For M2, learners must produce comprehensive designs for lighting, small power, data and fire alarm installations. The designs should include details of all items of electrical equipment, lighting, small power, data, fire alarms and security. Learners should relate their decisions to the needs of particular buildings and the proposed systems and outline any constraints and considerations. Learners are expected to use appropriate data to select perform lumen calculations using appropriate data and design the lighting layout. This could be a natural extension of the work carried out for P1, P2, P4, P5 and P6.

For M3, learners must produce clear and accurate answers to the calculations required to size low voltage power and lighting cables. This should include live and protective conductors. Learners are expected to extract and present the necessary data from these calculations. This could be a natural extension of the work carried out for P5.

For M4, learners must analyse installation drawings, design calculations and manufacturers' data to produce detailed specifications, schedules and data for lighting, power, data and fire alarm equipment. Learners are expected to use this data, in conjunction with manufacturers' information, to write specifications, select and produce schedules and commission information for lighting, power, data, and fire alarm equipment.

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 analyse and justify the design rationale used in the production of a lighting and power design; demonstrate how the proposed design meets the needs of the client and their building. In justifying the design learners should show how a proposed design meets the needs of the building, client and end users, as well as the wider issues of environmental impact. As part of the justification, learners are expected to link the features of the design with appropriate underpinning principles.

For D2, learners must analyse and justify the design parameters and rationale used in the sizing and specification of low voltage power cables, small power equipment and fixed plant. In justifying the design parameters learners must explain why they used particular parameters, what alternative parameters could be used and what the effect of using other parameters would be.

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

The learning outcomes in this unit are closely linked with, for example, *Unit 39: Electrical Principles in Building Services Engineering* and *Unit 40: Electrical Installation Standards and Components in Building Services Engineering*, together with similar units at Higher National and degree level.

This unit may have links to the Edexcel Level 3 Technical and Professional NVQs for Construction and the Built Environment. Updated information on this, and a summary mapping of the unit to the CIC Occupational Standards, is available from Edexcel. See *Annexe D: National Occupational Standards/mapping with NVQs*.

There are also links with Summit Skills N-SVQ Level 3: Building Services Engineering Technology and Project Management, in particular, Unit SST/NOS 3: Apply Design Principles to Building Services Engineering Projects and Unit SST/NOS 7: Provide Technical and Functional Information to Relevant People.

Summit Skills N-SVQ Level 4: Building Services Engineering Technology and Project Management, in particular, Unit SSTE/NOS 7: Prepare and Advise on Building Services Engineering Project Design Recommendations and Unit SSTE/NOS 8: Prepare and Agree Detailed Building Services Engineering Project Designs.

This unit presents opportunities to demonstrate key skills in application of number, communication, information and communication technology, improving own learning and performance, problem solving and working with others. Opportunities for satisfying requirements for Wider Curriculum Mapping are summarised in *Annex F: Wider curriculum mapping*.

Essential resources

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

Indicative reading for learners

Textbooks

Chartered Institution of Building Services Engineers — *Code for Lighting* (Butterworth-Heinemann, 2002) ISBN 0750656379

Chartered Institution of Building Services Engineers — *Guide K: Electricity in Buildings* (CIBSE, 2005) ISBN 190328726X

Construction Industry Training Board — Construction Skills — IEE Regulations Study Notes: *BS 7671 — Requirements for Electrical Installation, 16th Edition* (CITB, 2005) ISBN 1857510453

Cook P — *Commentary on IEE Wiring Regulations (BS 7671:2001): Requirements for Electrical Installations Amendment No.1 2002, 16th Edition* (Institution of Engineering and Technology, 2002) ISBN 0852962371

Hastings P — *The Illustrated Guide to Electrical Building Services, 2nd Edition* (BSRIA, 2005) ISBN 0860226530

Institution of Electrical Engineers — *Requirements for Electrical Installations: IEE Wiring Regulations, 16th Edition* (IEE, 2001) ISBN 0863413730

Miller H and Puckering R — *Electrical Installation Practice, 4th Edition* (Blackwell Science, 1993) ISBN 0632025425

Whitfield J — *The Electrician's Guide to the 16th Edition of the IEE Wiring Regulations, 8th Edition* (EPA Press, 2005) ISBN 0953788547

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:**
• producing clear and accurate answers to the calculations required to size low voltage power and lighting cables.	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 proportion 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:**
• describing how the features and characteristics of lamps and luminaires contribute to their selection for specific applications.	C3.1a Take part in a group discussion. C3.1b Make a formal presentation of at least eight minutes using an image or other support material. 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:**
• describing the requirements of the IEE Wiring Regulations in relation to current-carrying capacity of cables and protection against electric shock, high temperatures, over current and short circuit.	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.
Improving own learning and performance Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• producing comprehensive designs for lighting, small power, data and fire alarm installations.	LP3.1 Set targets using information from appropriate people and plan how these will be met. LP3.2 Take responsibility for your learning, using your plan to help meet targets and improve your performance. LP3.3 Review progress and establish evidence of your achievements.
Problem solving Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• making comparisons between alternative lamps, luminaires, and switching arrangements and making valid and appropriate recommendations for specific applications.	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.

Working with others Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• producing comprehensive designs for lighting, small power, data and fire alarm installations.	WO3.1 Plan work with others. WO3.2 Seek to develop co-operation and check progress towards your agreed objectives. WO3.3 Review work with others and agree ways of improving collaborative work in the future.