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

**NQF Level 3:** **BTEC National**

**Guided learning hours: 60**

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## 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 standards applicable to 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. The aim of this unit is to provide learners with that understanding.

The first part of the unit explores the Institute of Electrical Engineers (IEE) Requirements BS: 7671 and looks at the scope, object and fundamental principles for safety. The relationship with statutory regulations is addressed, as is the assessment of the general characteristics that are associated with electrical installations.

The focus of the unit is on linking principles with practical refrigeration applications, and learners should therefore have achieved a basic understanding of the associated science, technology and analytical methods, or have begun studying these, before undertaking it.

## Learning outcomes

**On completion of this unit a learner should:**

1 Be able to interpret regulations and legislation related to electrical installations

2 Understand wiring techniques

3 Understand earthing and bonding principles

4 Be able to determine the need for final circuits and circuit protection

5 Know the requirements for special installations.

## Unit content

1 **Be able to interpret regulations and legislation related to electrical installations**

*Institution of Electrical Engineers (IEE) Regulations*: scope and objective, fundamental principles for safety

*Relationship with statutory regulations*: Electricity Supply Quality Continuity Regulations; Health and Safety at Work Act 1974; Electricity at Work Regulations 1989; The Building Regulations; CDM Regulations; Electricity Equipment Safety Regulations 1994; The Electromagnetic Compatibility Regulations 1992

*Assessment of general characteristics*: purposes; supplies and structure; external influences; compatibility; maintainability

2 **Understand wiring techniques**

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

*Other installation methods*: basket, ladder rack

*Segregation of circuits*: categories of circuits

*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

*Flexible cords, extra low and low voltage cables for power, audio and high frequency transmission*: details of their construction; features and materials used; advantages, 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**

*Protection against electric shock*: nature of electric shock; resistance of electric shock; direct and indirect contact; 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 **Be able to determine the need for final circuits and circuit protection**

*Circuits type*: fused plug; socket outlet; ring circuit; radial and tree circuits; industrial socket outlets; lighting; cooker; off-peak

*Protection against thermal effects*: from burns and fire

*Over current protection*: characteristics and limitations of devices such as fuses and circuit breakers

5 **Know the requirements for special installations**

*IEE regulations requirements for*: bath tubs, showers and basins within bathrooms and other rooms, swimming pools, sauna rooms; equipment with high earth currents; construction sites; highway supplies and street furniture; heating appliances and their installation; electrode boilers; instantaneous water heaters; floor, soil and road warming; high voltage discharge lighting; reduced voltage systems

## 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 describe 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 general requirements of regulations and legislation related to the provision of electricity within buildings | M1 make valid and appropriate decisions relating to the application of regulations and legislation for specific electrical installations within buildings | D1 reliably evaluate a range of installations for compliance with relevant legislation and regulations |
| P2 describe the operational features, characteristics and applications of common cables, flexible cords, containment methods and installation techniques within buildings | M2 compare the alternative wiring systems and techniques for specific electrical installations and evaluate the most appropriate for use | D2 analyse and justify the wiring and installation techniques, materials and equipment proposed for a range of proposed installations. |
| P3 describe the requirements, operational features, characteristics and application of electrical earth and other shock protection techniques and installations | M3 produce clear and accurate answers to problems relating to the specification of protective conductors, earthing and similar protective installations | |
| P4 explain the operational features, characteristics and application of residual current devices | M4 produce clear and accurate answers to problems relating to the specification of final circuits | |

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| 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 application and use of the various types of final circuit within buildings and the techniques used to determine diversity and maximum demand<br><br>P6 identify the operational characteristics and applications of common over current and short circuit protection devices. | M5 evaluate and compare alternative types and forms of common short circuit and overload devices and make valid and appropriate decisions relating to the needs of particular buildings, client needs and constraints. | |

## 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.

Some 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 in the delivery of this unit.

This unit could 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.

The focus of this unit is on linking principles with practical applications. This implies that learners will have achieved a basic understanding of 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 approach is used then suitable evidence would be observation records or witness statements. Guidance on the use of these 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 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 equally important that any buildings selected are not too complex; they should be capable of realistically incorporating conventional final circuits, motors, drives and other items of fixed plant.

Learners should be provided with 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 concurrently studying other units, the 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 single assessment instrument designed to meet the grading criteria for this unit.

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

For P1, learner must identify the general requirements of regulations and legislation related to the provision of electricity within buildings. Although statutory legislation should be explored, a strong focus should be placed on BS:7671.

For P2, learners must describe the operational features, characteristics and applications of common cables, flexible cords, containment methods and installation techniques within buildings. These should include single-core and multicore 70OC thermoplastic, 90OC thermosetting, armoured and non-armoured, cables clipped direct, in conduit, trunking, on tray and in basket. Learners do not need to make recommendations of 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 requirements, operational features, characteristics and application of electrical earth and other 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 P4, learners must explain the operational features, characteristics and application of residual current devices. This should be when used as supplementary protection against shock.

For P5, learners must describe the application and use of the various types of final circuit within buildings and the techniques used to determine diversity and maximum demand. There should be evidence that learners understand the procedure used.

For P6, learners must identify the operational characteristics and applications of common over current and short circuit protection devices. Learners do not need to make recommendations of particular strategies for specific applications, but they are expected to contextualise their descriptions by indicating typical applications and criteria which might influence their selection.

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

For M1, learners must make valid and appropriate decisions relating to the application of regulations and legislation for specific electrical installations within buildings. This should include locations with special installation requirements. Learners should relate their decisions to the needs of a particular client and the features, form and activities of the building. This could be a natural extension of the work carried out in P1.

For M2, learners must compare the alternative wiring systems and techniques for specific electrical installations and evaluate the most appropriate for use. Learners should relate their decisions to the needs of particular buildings and the proposed systems and outline any constraints and considerations. This could be a natural extension of the work carried out in P2

For M3, learners must produce clear and accurate answers to problems relating to the specification of protective conductors, earthing and similar protective installations. 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. This could be a natural extension of the work carried out in P2.

For M4, 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 P5.

For M5, learners must evaluate and compare alternative types and forms of common short circuit and overload devices and make valid and appropriate decisions relating to the needs of particular buildings, client needs and constraints. This could be a natural extension of the work carried out in P6.

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 reliably evaluate a range of installations for compliance with relevant legislation and regulations. In justifying the design learners must clearly show how a proposed design meets the needs of the building, client and end users as well as the wider issues of environment 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 wiring and installation techniques, materials and equipment proposed for a range of proposed installations. In justifying the design parameters learners must clearly explain why they used particular parameters, what alternative parameters could be used and what the effect of using other parameters would be. As part of the justification learners are expected to make the link with appropriate underpinning principles.

**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 41: Electrical Installation Design 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.

Also of relevance is Summit Skills N-SVQ Level 4: Building Services Engineering Technology & 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.

The unit provides opportunities to gain Level 3 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. The centre should work closely with building services contractors, architects and manufacturers in order to provide realism and relevance to the project work.

## Indicative reading for learners

### Textbooks

Construction Industry Training Board-ConstructionSkills — 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

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 problems relating to the specification of protective conductors, earthing and similar protective installations. | N3.1 Plan an activity and get relevant information from relevant sources.<br>N3.2 Use this information to carry out multi-stage calculations to do with:<br>a amounts or sizes<br>b scales or proportion<br>c handling statistics<br>d using formulae.<br>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:** |
| • identifying the general requirements of regulations and legislation related to the provision of electricity within buildings. | C3.1a Take part in a group discussion.<br>C3.1b Make a formal presentation of at least eight minutes using an image or other support material.<br>C3.2 Read and synthesise information from at least **two** documents about the same subject.<br>Each document must be a minimum of 1000 words long.<br>C3.3 Write **two** different types of documents, each one giving different information about complex subjects.<br>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 operational features, characteristics and applications of common cables, flexible cords, containment methods and installation techniques within buildings. | ICT3.1 Search for information, using different sources, and multiple search criteria in at least one case.<br>ICT3.2 Enter and develop the information and derive new information.<br>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:** |
| • comparing the alternative wiring systems and techniques for specific electrical installations and evaluating the most appropriate for use. | LP3.1 Set targets using information from appropriate people and plan how these will be met.<br>LP3.2 Take responsibility for your learning, using your plan to help meet targets and improve your performance.<br>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:** |
| • producing clear and accurate answers to problems relating to the specification of final circuits. | PS3.1 Explore a problem and identify different ways of tackling it.<br>PS3.2 Plan and implement at least one way of solving the problem.<br>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:** |
| • evaluating and comparing alternative types and forms of common short circuit and overload devices and making valid and appropriate decisions relating to the needs of particular buildings, client needs and constraints. | WO3.1 Plan work with others.<br>WO3.2 Seek to develop co-operation and check progress towards your agreed objectives.<br>WO3.3 Review work with others and agree ways of improving collaborative work in the future. |