

**Note:**

*These units form the Level 3 aspects of electrical trade specific area of the apprenticeship qualification knowledge, understanding and performance units.*

*Within the apprenticeship qualification there will also be the also be L2 **trade specific** units as given in the progression document.*

*I.E: Apprentices will undertake all the same electrical units at L2 as shown in the progression qualification document e.g. they will learn and be assessed on Ohm's law in unit 208 before inductive reactance in unit 308! As given in this document.*

**Unit Ref 301P**

**Apply health and safety and environmental  
legislation in the building services engineering  
sector**

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**GLH:**

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**What is this unit about?**

**This is a performance unit** and is about establishing and maintaining working practices and procedures to health and safety, the natural environment and the working environment. This would include identifying hazards and risks, applying appropriate procedures and working practices to protect yourself and others.

The learner must possess the skills and knowledge to be able to use building services engineering sector equipment, components, materials and substances effectively, efficiently, in accordance with the specification giving consideration to the natural environment and the working environment in terms of waste materials.

## Performance Criteria

### NOS outcome:

1. **Identify the appropriate industry standards and regulations.**

### NOS outcome:

2. **Apply relevant organisational procedures.**

**Scope and range:** organisation procedures:

- 2.1 information management
- 2.2 method statement
- 2.3 project management
- 2.4 risk assessment
- 2.5 implementing and monitoring health and safety requirements and issues
- 2.6 implementing and monitoring issues relating to the natural environment
- 2.7 customer services
- 2.8 accident reporting
- 2.9 emergencies
- 2.10 communication with relevant people.

### NOS outcome:

3. **Identify hazards and risks.**

**Scope and range:** hazards and risks (internal and/or external):

- domestic
- non-domestic (commercial, industrial, agricultural, horticultural, leisure and entertainment, residential medical and care facilities, public highways and parks, public services establishments, pre-1919 traditional/historic buildings).

**AND**

**Scope and range:** site:

- new build construction – building or structure
- existing building or structure.

### NOS outcome:

4. **Complete documentation in accordance with the requirements of the organisational procedures.**

**NOS outcome:**

5. **Review the organisational procedures to ensure that they will not cause potential hazards and risks.**

**Scope and range:** potential hazards and risks:

- 5.1 disposal of substances and materials
- 5.2 installation and/or maintenance methods and techniques
- 5.3 lifting and handling (manual and mechanically assisted)
- 5.4 presence of vehicle thoroughfares
- 5.5 storage of liquids, substances and materials
- 5.6 use of appliances, tools and equipment
- 5.7 use of access equipment
- 5.8 use of personal protective equipment (PPE)
- 5.9 working in a potentially hazardous atmosphere (e.g. presence of asbestos, dust, fumes or vapour)
- 5.10 working at height
- 5.20 working in confined spaces.

**NOS outcome:**

6. **Implement organisational procedures, suppliers' and manufacturers' instructions appropriate to the safe use, maintenance, handling, transport and storage of:**
- **Tools, plant and access equipment**
  - **Equipment and components**
  - **Materials and substances.**

**NOS outcome:**

7. **Report to the relevant people in accordance with organisational procedures potential hazards and risks, potentially harmful materials and substances.**

**Scope and range:** relevant people:

- 7.1 customers/clients
- 7.2 client representatives
- 7.3 supervisors
- 7.4 site/contract manager
- 7.5 other contractors/trades
- 7.6 members of the public
- 7.7 work colleagues.

**NOS outcome:**

8. **Confirm that the conduct of people when undertaking the installation and/or maintenance activity does not cause potential hazards and risks**

**NOS outcome:**

9. **Comply with organisational procedures in the event of: injuries to self and/or others, emergencies, evacuation procedures.**

**Scope and range:** injuries/emergencies/evacuation:

- 9.1 fire
- 9.2 flood
- 9.3 explosion
- 9.4 toxic atmosphere
- 9.5 electric shock
- 9.6 injury to person(s).

**NOS outcome:**

10. **Implement organisational procedures for the safe transport and/or disposal of waste material, substances and liquids in accordance with suppliers' and manufacturers' instructions.**

## Unit Ref 302

## Establish and maintain relationships in the building services engineering sector

GLH:

### What is this unit about?

This unit consists of knowledge, understanding and performance and is for learners who are required to develop and maintain positive relationships with clients and customers associated with the installation and/or maintenance activities in the building services engineering sector in accordance with:

- appropriate industry standards and regulations
- the specification
- working practices
- the working and natural environment.

The learner will have the responsibility for establishing and maintaining client and customer relationships and will be able to:

- present and provide accurate technical and functional information, advice and guidance
- liaise with clients and customers with respect to their needs and expectations
- respond as appropriate to client and customer needs and expectations.

## **Underpinning knowledge and understanding**

### **NOS outcome:**

1. The importance of customer service in relation to installation and/or maintenance activity

### **NOS outcome:**

2. How to identify the clients and customers that need to be supplied with technical and functional information

### **NOS outcome:**

3. Sources of technical and functional information such as:
  - The specification for the building services engineering system
  - The specification for the installation and/or maintenance activity
  - The manufacturer's instructions.

### **NOS outcome:**

4. The responsibilities and limitations of your job role with respect to supplying technical and functional information.

### **NOS outcome:**

5. The technical and functional information that you are providing and its implications on the operation of the building services engineering system and/or its equipment, accessories and components that have been installed and/or maintained.

### **NOS outcome:**

6. The organisational procedures and policies regarding the handover and demonstration of a building services engineering system and/or its equipment, accessories and components that have been installed and/or maintained.

### **NOS outcome:**

7. The operating principles, controls and settings of the building services engineering system and/or its equipment, accessories and components that have been installed and/or maintained importance of providing technical and functional information clearly, courteously and professionally.

### **NOS outcome:**

8. The methods and organisational procedures for establishing positive relations with clients and customers.

### **NOS outcome:**

9. The working requirements and practices of the clients and customers in the working environment where the installation and/or maintenance activity is taking place.

### **NOS outcome:**

10. Which situations warrant written technical and functional information.

**NOS outcome:**

11. The safety implications and operational consequences of supplying inaccurate or incomplete technical and functional information to clients and customers.

**NOS outcome:**

12. Methods of checking the clients' and customers' understanding of the technical and functional information provided.

**NOS outcome:**

13. Legislation regarding health and safety, data protection, equal opportunities.

**NOS outcome:**

14. Opportunities and regulations that affect the way that technical and functional information is delivered to clients and customers.

**NOS outcome:**

15. The clients' and customers' rights including any contractual agreements.

**Delivery advice (depth of content)**

This unit builds upon and compliments the learner's prior knowledge. The unit additionally underpins the rest of this qualification.

Learners will understand what is meant by technical and functional information and their responsibilities (as relevant) for the accurate and precise recording, retention and handover of technical and functional information.

Learners will understand of the importance of technical communication to a range of personnel.

They will understand the main requirements to process technical and functional information in compliance with the key principles of the Data Protection Act (the UK's implementation of the General Data Protection Regulation (GDPR)) and the clients/customers basic rights under the Consumer Rights Act. The main points of the Equality Act.

## Performance Criteria

### NOS outcome:

1. Identify the clients and customers that need to be supplied with technical and functional information

### NOS outcome:

2. Obtain the current and relevant technical and functional information that needs to be provided to the clients and customers

### NOS outcome:

3. Provide accurate guidance and advice to the clients and customers on technical and functional matters associated with the building services engineering system that has been installed and/or maintained in terms of:
  - Health and safety issues
  - Safe and effective operation

### NOS outcome:

4. Provide information in accordance with organisational procedures

**Scope and range:** organisation procedures:

- 4.1 information management
- 4.2 method statement
- 4.3 project management
- 4.4 risk assessment
- 4.5 implementing and monitoring health and safety requirements and issues
- 4.6 implementing and monitoring issues relating to the natural environment
- 4.7 customer services
- 4.8 accident reporting
- 4.9 emergencies
- 4.10 communication with relevant people.

### NOS outcome:

5. Demonstrate to the clients and customers, as appropriate, the operation of the building services engineering system that has been installed and/or maintained

**Scope and range:** working environment of the system (internal and/or external):

- 5.1 domestic
- 5.2 non-domestic (commercial, industrial, agricultural, horticultural, leisure and entertainment, residential medical and care facilities, public highways and parks, public services establishments, pre-1919 traditional/historic buildings).

**NOS outcome:**

**6. Confirm in relation to the installation and/or maintenance activity:**

- The client and customer expectations and requirements
- The building services engineering system is in a satisfactory condition
- The hand over process

**NOS outcome:**

**7. Establish and maintain productive working relationships with clients and customers, including dealing with disagreements in an amicable and constructive way, so that good relationships are maintained**

**NOS outcome:**

**8. Respond effectively to requests for technical and functional information from clients and customers**

**NOS outcome:**

**9. Report, record and recommend, in accordance with organisational procedures and as appropriate, any variation to the installation and/or maintenance activity to the clients, customers and other relevant people**

**Scope and range:** relevant people:

- 9.1 customers/clients
- 9.2 client representatives
- 9.3 supervisors
- 9.4 site/contract manager
- 9.5 other contractors/trades
- 9.6 members of the public
- 9.7 work colleagues.

**NOS outcome:**

**10. Comply with organisational standards for appearance and behaviour**

**Unit Ref 303**

**Unit Title Coordinate a work site in the  
building services engineering sector**

**GLH:**

**What is this unit about?**

This unit consists of knowledge, understanding and performance. It covers how to coordinate the work site for the installation and/or maintenance activities associated with building services engineering systems.

It covers the responsibility for the coordination of the work site and learners must be able to oversee, as relevant, the work of other operatives and/or other contractors, in accordance with relevant industry standards, regulations and the specification, working practices, the working environment and the natural environment to confirm:

- the work to be undertaken
- a programme of work with relevant people
- the organisation of the appropriate resources
- that equipment, accessories and components are fit-for-purpose
- that work is carried out safely
- all relevant documentation is completed accurately.

The learner will understand the extent of their role and responsibilities, including how best to motivate, monitor and communicate with others in accordance with organisational procedures.

## **Underpinning knowledge and understanding**

### **NOS outcome:**

#### **1. Your role and responsibilities in relation to:**

- Monitoring and implementing health and safety on the work site
- The work to be undertaken
- Allocating roles and responsibilities
- Identifying resources required
- Monitoring the work of operatives
- Liaising with relevant people.

### **NOS outcome:**

#### **2. How to interpret organisational procedures and monitor changing conditions at the work site.**

### **NOS outcome:**

#### **3. How to coordinate operatives you are responsible for in relation to:**

- Supervision and motivation
- Identification of competence
- Planning work allocations, duties and responsibilities.

### **NOS outcome:**

#### **4. How to communicate effectively with relevant people.**

### **NOS outcome:**

#### **5. The current versions of appropriate industry standards and regulations relevant to the identified building services engineering system.**

### **NOS outcome:**

#### **6. The organisational procedures for:**

- Completing the necessary documentation
- Agreeing a programme of work with relevant people
- Confirming that the installation and/or maintenance work is completed
- Identification of competence.

### **NOS outcome:**

#### **7. Methods that will verify that the equipment, accessories and components are:**

- Compatible to the working environment
- In accordance with the specification
- Of the required and correct type
- Delivered on time and undamaged
- Suitable and safely stored.

### **NOS outcome:**

#### **8. How to manage the available storage facility at the work site.**

### Delivery advice (depth of content)

In this unit learners will understand their responsibilities in overseeing and organising work activities and the work environment. They will understand how to ascertain the competence of different relevant colleagues and workers, how to allocate work activities and how to monitor that the work is being completed on time to the work schedule.

Learners will understand how to interpret the installation specification and work programme to identify resource requirements such as: materials, components, plant, vehicles, equipment, labour, tools and equipment. The storage and transportation requirements for the required materials.

They will understand how to liaise with other relevant people on site to enable the work to be completed this includes customers, clients, site managers, major contractors (where appropriate), sub-contractors (where appropriate), other services and trades, the public and their employer.

They will understand how to create schedules of work including a Gantt chart including and the critical path. They will understand how the work completion time is estimated considering influential factors such as the deployment and availability of suitable personnel, the delivery and availability of equipment, components and material weather conditions, and work to be completed by other services. The procedures for dealing with changes to an original contract specification including variation orders, day work sheets.

Learners will understand how to how to plan and implement work allocations and the duties of operatives for whom they are responsible and the effective coordination with other services and personnel.

They will ensure that they maintain the safety of the work environment, cost effectiveness; and ensure compliance with the specification and work schedule; how to communicate effectively with others for the purpose of motivation, instruction, monitoring, co-operation, and teamwork.

They will recognise the industry standards of regulations relevant to their work. The general legislation that applies includes the Employment Rights Act, Data Protection Act, Equality Act, and the Human Rights Act.

They will recognise the possible consequences of **not** completing work within the scheduled time, or using the specified materials, or not installing materials and equipment as specified or meeting the requirements of the programme of work.

## Performance Criteria

### NOS outcome:

- 1 Produce a risk assessment and method statement for the work to be carried out on the identified building services engineering system.

**Scope and range:** working environment of the system (internal and/or external):

- 1.1 domestic
- 1.2 non-domestic (commercial, industrial, agricultural, horticultural, leisure and entertainment, residential medical and care facilities, public highways and parks, public services establishments, pre-1919 traditional/historic buildings).

### NOS outcome:

- 2 Allocate duties and responsibilities to operatives, when appropriate, to make best use of their competence.

### NOS outcome:

- 3 Instruct the operatives, where relevant, about their duties and responsibilities clearly and concisely.

### NOS outcome:

- 4 Confirm that any instructions given are understood.

### NOS outcome:

- 5 Coordinate effectively, when relevant, the work of other contractors.

### NOS outcome:

- 6 Monitor, as appropriate, that the work of operatives is safe, fit-for- purpose, cost effective and in accordance with:
  - Industry recognised working practices
  - The specification
  - The current versions of appropriate industry standards and regulations.

### NOS outcome:

- 7 Ensure that safe and appropriate action is taken promptly where a non-compliance is identified during the programme of work.

**NOS outcome:**

- 8 Ensure that all documentation associated with the installation and/or maintenance work is in accordance with organisational procedures, the current versions of appropriate industry standards and regulations.**

**Scope and range:** organisation procedures:

- 8.1 information management
- 8.2 method statement
- 8.3 maintenance (planned and reactive)
- 8.4 project management
- 8.5 risk assessment
- 8.6 implementing and monitoring health and safety requirements and issues
- 8.7 implementing and monitoring issues relating to the natural environment
- 8.8 customer services
- 8.9 accident reporting
- 8.10 emergencies
- 8.11 communication with relevant people.

**NOS outcome:**

- 9 Liaise with the relevant people to resolve issues which are outside the scope of your job role.**

**Scope and range:** relevant people:

- 9.1 customers/clients
- 9.2 client representatives
- 9.3 supervisors
- 9.4 site/contract manager
- 9.5 other contractors/trades
- 9.6 members of the public
- 9.7 work colleagues.

**NOS outcome:**

- 10 Verify that the equipment, accessories and components are:**

- Compatible to the working environment
- In accordance with the specification
- Of the required and correct type
- Delivered on time and undamaged
- Suitable and safely stored.

**NOS outcome:**

- 11 Confirm that the installation and/or maintenance work completed is in accordance with:**

- The specification
- The current versions of appropriate industry standards and regulations.

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GLH:	
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### What is this unit about?

This unit covers the **understanding** required for the:

- installation of **enclosures** for electrical cables, conductors and wiring systems internally and externally for electrical systems.
- installation and connection of **electrical cables, conductors**, wiring systems, equipment, accessories and components for electrical systems.

**It covers the performance requirements** for the installation of enclosures for electrical cables, conductors and wiring systems internally and externally for electrical systems.

*(Note that Unit 305 covers the **performance requirements** for the installation and connection of **electrical cables, conductors**, wiring systems, equipment, accessories and components for electrical systems).*

The learner must be able to comply with the procedures and methods for installing enclosures for electrical cables, conductors and wiring systems in accordance with the current versions of the appropriate industry standards and regulations, the specification, industry recognised working practices, the working environment and the natural environment.

They will **understand** the different types of enclosures for electrical cables, conductors and wiring systems, their limitations, applications and the techniques for the positioning, fitting, fixing and connection of the enclosures, their components and accessories.

**Guidance:** Within this unit learners will utilise the requirements of BS 7671. They will be able to locate, interpret, apply relevant requirements of the standard. This will build upon the learner's knowledge of the main relating requirements of the IET On-Site Guide covered in unit 204 and 205.

## Knowledge and Understanding

### NOS outcome:

#### 1. The operation, applications, advantages and limitations of different electrical systems

##### Scope and range

##### 1.1 Electrical systems: earthing systems

###### Range:

- TN-S
- TN-C-S
- TN-C
- TT
- IT.

##### 1.2 Electrical systems: supply systems

**Range:** single phase, three phase, three phase and neutral.

##### 1.3 Electrical systems: circuits

**Range:** distribution systems (sub mains), environmental control/building energy management systems, UPS, Closed Circuit TV, communication and data transmission systems, protective systems (fire alarm/prevention; unlawful entry; emergency lighting), machine control, heating control, final circuits (including circuits for electric vehicle charging equipment).

##### 1.4 The arrangements for electrical installations and systems with regards to provision for: isolation and switching, overcurrent protection, earth fault protection.

##### 1.5 Devices for protection against the risk of fire: AFDDs, RCDs.

##### 1.6 The maximum disconnection times for circuits.

##### 1.7 Protection against overvoltage and the types and applications of SPDs

##### 1.8 Protection against undervoltage

##### 1.9 The requirements for protection against electric shock.

##### 1.10 Requirements and applications of functional earthing.

##### 1.11 Selecting suitably sized protective conductors in accordance with BS 7671.

**NOS outcome:**

**2. The appropriate industry standards and regulations relevant to installing enclosures**

**Scope and range**

**2.1 Industry standards and regulations**

**Range:** Interpretation and the application of the main topics in BS 7671, Building Regulations Wales and England (relevant Approved Documents and technical guidance for Wales), industry/manufacturers guidance IET OSG, relevant requirements of the Construction (Design and Management) Regulations, Electricity at Work Regulations, Health and Safety at Work Act, Provision and Use of Work Equipment Regulations, Personal Protective Equipment at Work Regulations.

**NOS outcome:**

**3. The applications, advantages and limitations of types of enclosures**

**Scope and range**

3.1 Selection of wiring systems and equipment appropriate to the situation and use utilising BS 7671.

3.2 Application of the Degrees of Protection Provided by Enclosures (IP Code).

**NOS outcome:**

**4. The organisational procedures for confirming with the relevant people the appropriate actions to be taken to ensure that any variations to the planned programme of work will not introduce a hazard and have minimum negative impact on the installation work to be undertaken**

**NOS outcome:**

**5. The appropriate industry standards and regulations relevant to installing and connecting electrical cables, conductors, wiring systems, associated equipment, accessories and components**

**Scope and range**

**5.1 Industry standards and regulations**

**Range:** Interpretation and the application of BS 7671, Building Regulations and relevant Approved Documents and technical guidance, industry/manufacturers guidance, and standards, IET Publications (e.g. Guidance Notes and the On-Site Guide).

**NOS outcome:**

- 6. The industry recognised methods for determining the type, size and rating of electrical cables, conductors, wiring systems, associated equipment, accessories and components in relation to the electrical system's design**

**Scope and range** (single and three phase)

6.1 Interpretation of manufacturer's data for the selection and application of connected loads and equipment.

6.2 Selection of current using equipment considering energy efficiency.

6.3 Interpretation and the application of the main topics in BS 7671.

6.4 Application of smart technology when used for convenience, comfort, safety, and security.

6.5 Cable selection:

- establishing the maximum demand of an installation after the application of diversity
- determining the circuit design current
- selection of a suitably rated protective device
- establishing the installation method reference
- determining appropriate rating factors
- determining the minimum cross-sectional area of live conductors taking into consideration current carrying capacity and voltage drop
- establishing if the voltage drop is acceptable
- determining if the disconnection time will be met
- evaluating the cables thermal withstand (during a fault).

## **Delivery advice (depth of content)**

### **Learners will understand:**

**1.1** The characteristics, applications, advantages and limitations of earthing arrangements (The earthing arrangements as shown in BS 7671). TN-S, TN-C-S (also cover meaning of PME), TN-C, TT, IT systems (specialist use such as in operating theatres). The meaning of PME, and a PEN conductor. Obtain an understanding of the principle of foundation earthing.

**1.2** The characteristics, applications, advantages and limitations of supply systems, this encompasses supplies to an installation from the DNO and supplies to distribution circuits and final circuits (consumer circuits). Also cover some situations that have two-phase supplies.

**1.3** Learners will gain an understanding of the principles of the range of circuits listed, how these circuits operate where they are applied their advantages and their limitations. Note that some of these circuits have synergy with the science and principles unit so will be explored further (e.g. machine control).

**1.4 – 1.9** Learners will interpret the requirements of BS 7671 for the topics listed and how these requirements apply to circuits. They will be able to locate regulations and utilise tabulated information, perform calculations and evaluate compliance. The requirements for overcurrent protection and earth fault protection including disconnection times in Chapter 41 of BS 7671.

Selectivity, breaking capacity, and fault current capacities of devices. Types and uses of RCDs including selectivity between RCDs. Give an overview of moulded case circuit breakers and air circuit breakers.

Arc fault protection and the advantages, applications, limitations of arc fault detection devices (AFDDs). Types of arc faults.

The use of RCDs when used for protection against the risk of fire. The types and applications of surge protective devices. Refer to BS 7671 including Appendix 16. Cover calculated risk level CRL for the use of SPDs.

The requirements for protection against overvoltage and undervoltage.

Learners will be able to interpret and relate the requirements for protection against electric shock (Chapter 41 of BS 7671).

The requirements of functional earthing. The use of Chapter 54 of BS 7671 to selecting suitably sized protective conductors.

**2** Learners will understand the application of BS 7671 for the design, selection and erection of electrical installations (commissioning covered in a following unit). They will be able to locate, interpret and understand the main topics of BS 7671 and its appendices relating to electrical work in a variety of locations/contexts. They will also understand how to interpret the requirements of other related publications listed in the range and the relationship between the various industry standards and regulations. The scope of Part P in Wales and England (supporting portability and cross border working). Give learners an awareness only of the specialist requirements for electrical equipment in potentially explosive atmospheres.

**3** Learners will be able to utilise BS 7671 to select appropriate wiring systems and equipment (for example in a special location) and to account for external influences. They will understand the requirements the IP code in relation to how this applies to electrical installations and selecting appropriate electrical equipment and enclosures (link to requirements of BS 7671 barriers and enclosures etc.). Factors which affect the selection of wiring systems and equipment: client specification, cost, efficiency of equipment, speed of installation of different wiring systems, ergonomics and future maintenance of the installation. Cover considerations of using the metallic enclosure as CPC, such as greater maintenance requirements. Cover considerations of selecting enclosures and containment in a range of contexts.

**4 -6** Learners will be able to interpret the requirements of BS 7671 for key topics. They will know the requirements as outlined in the Building Regulations (Wales and England) relevant Approved Documents and technical guidance applicable to electrical work. The use of industry/manufacturers guidance, and standards, IET Publications (e.g. Guidance Notes and the On-Site Guide).

To support this where necessary also refer to the relevant requirements of the Construction (Design and Management) Regulations, Electricity at Work Regulations, Health and Safety at Work etc. Act, Provision and Use of Work Equipment Regulations, Personal Protective Equipment at Work Regulations. Highlight the requirements for escape routes.

Learners will be able to utilise tabulated data, regulations and the relevant methods and procedures to select appropriately sized cables for given applications (for single and three- phase circuits) including maintainability. Link to unit 308 reactive loads – such as lighting and the 1.8 factor from the IET On-Site Guide. Applications of overcurrent protective devices for loads.

They will be able to appreciate the application of smart technology. Note that this aspect builds upon unit 204 (lighting) and links to unit 308 (heating controls). How smart homes can facilitate energy saving, comfort, fire safety, and security. Smart offices, and the internet of things (IoT).

The importance of sustainability in the selection and application of low energy equipment and controls. Refer to Appendix 17 of BS 7671. Part L of the Building Regulations and guidance in Approved Documents such as in relation to internal/external lighting, electric heating etc. They will have an awareness of PAS 2030.

**Further note: the requirements of BS 7671 should be delivered in a similar way to the wiring regulations award, but in an expanded capacity over a longer time frame to enable learners to become familiarised and immersed into BS 7671. This will be pivotal in underpinning the entire qualification.**

## Performance Criteria

1. Assess and apply appropriate procedures to include
  - adopting appropriate PPE
  - following a safe system of work (e.g. working in accordance with a risk assessment and method statement)
  - selecting appropriate tools/equipment for the installation work.
2. Prepare to install wiring systems, enclosures and associated equipment, to include:
  - confirm secure site storage facilities for tools,
  - equipment, materials and components
  - select materials (equipment and components) in accordance with the installation specification
  - report any pre-work damage/defects to existing equipment or building features, to the relevant person (Such as: customer/client, site/line manager)
  - confirm site readiness for installation work to begin
  - confirm authorisation for the installation work to start.
3. Use documentation to confirm that materials and equipment is of the correct quantity and is free from damage.
4. Ensure the planned locations for the wiring system and associated equipment are compatible with other building services (e.g. gas, water or other electrical services).
5. Check the planned locations for the wiring system in terms of:
  - aesthetic appearance
  - external influences.
6. Use sources of information to enable the installation of wiring systems, enclosures and associated equipment to be carried out including:
  - specifications
  - work schedules/programmes
  - manufacturer instructions
  - layout Drawings
  - other appropriate source of information (e.g. BS 7671 , other plans or diagrams, 'approved documents', building regulations).
7. Use appropriate measuring and marking out techniques which are appropriate to the wiring system, wiring enclosure and/or associated equipment that is being installed.

8. Install cables in accordance with BS 7671, the installation specification and programme of work: Cover Four:
  - single core (singles)
  - multicore insulated
  - PVC - PVC flat profile cable
  - MICC
  - fire performance
  - SWA cable
  - GSWB galvanised steel wire braid
  - Data cable.
9. Install the wiring systems in accordance with BS 7671, the installation specification and agreed planned programme of work: Cover Four:
  - PVC Conduit
  - metallic Conduit
  - PVC Trunking
  - metallic Trunking
  - cable Tray
  - cable Basket
  - ladder systems
  - ducting
  - modular wiring systems
  - busbar systems or powertrack.
10. Install electrical equipment and accessories, in accordance with BS 7671, the installation specification, manufacturers' instructions and the programme of work: Cover Four:
  - isolators /switches
  - socket-outlets
  - distribution-boards / consumer control units
  - overcurrent protective devices
  - luminaires
  - data socket outlets
  - other appropriate equipment (e.g. heating system components, control equipment).
11. Communicate with others professionally and appropriately to aid the effective installation of the wiring system/equipment.
12. Dispose of waste materials in accordance with site procedures and statutory requirements.
13. Ensure the installed wiring system/s and enclosure/s meet specified requirements including that they:
  - are the correct type and fit for purpose
  - are installed in accordance with BS 7671
  - meet the installation specification/other

- relevant plans/instructions
- are installed in accordance with any relevant manufacturer instructions.

DRAFT

**Unit Ref 05**

**Unit Title Install and connect electrical cables, conductors, wiring systems and equipment**

**GLH:**

**What is this unit about?**

This standard is for people who install and connect electrical cables, conductors, wiring systems, equipment, accessories and components for electrical systems (ac/dc).

The person carrying out this work must be able to comply with the procedures and methods for installing and connecting electrical cables, conductors, wiring systems, equipment, accessories and components in accordance with the current versions of the appropriate industry standards and regulations, the specification, industry recognised working practices, the working environment and the natural environment. They must know and understand the different types of cables, conductors, wiring systems, equipment, accessories and components, their limitations, applications and the techniques for their positioning, fitting, fixing and connection

## Performance Criteria

1. Evaluate and apply appropriate procedures to include:
  - selecting appropriate tools/equipment to enable termination and connection
  - adopting appropriate PPE
  - following a safe system of work (e.g. risk assessment, method statement, permit to work procedure).
2. Assess and confirm it is safe to complete termination and connection in terms of:
  - checking for presence of supply/carrying out safe isolation
  - mechanical soundness of the electrical equipment to be connected to
  - checking for unsafe situations.
3. Terminate and connect cables and conductors in accordance with manufacturers instructions, BS 7671, and any relevant drawing or specification: Cover Four:
  - single core cable (singles)
  - multicore insulated cable
  - PVC / PVC flat profile cable (twin and earth)
  - MICC cable
  - fire performance (such as FP 200 etc.)
  - SWA cable
  - GSWB galvanised steel wire braid
  - data cable.
4. Connect to electrical equipment in accordance with manufacturers instructions, BS 7671, and any relevant drawing or specification: Cover Five:
  - isolators /switches
  - socket outlets
  - distribution-boards / consumer control units
  - luminaires
  - electric motors / motor control equipment
  - overcurrent protective devices
  - earthing terminals
  - control panels
  - data socket outlets or data connections
  - fire detection/alarm components .
  - other appropriate equipment (such as: heating system components etc.).

**5. Terminate and connect conductors, using appropriate methods: Cover Two:**

- screwing
- crimping
- soldering
- non-screw compression
- insulation displacement.

**6. Ensure that terminations and connections are electrically and mechanically sound (e.g. by simple inspecting and testing terminations).**

**7. Ensure cables have appropriate identification in accordance with BS 7671.**

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**GLH:**

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**What is this unit about?**

This unit covers the **understanding and performance requirements** for the commissioning of electrical systems and equipment.

The learner must be able to comply with the processes and procedures for the commissioning and handing over of an electrical system and equipment in accordance with the current versions of the appropriate industry standards and regulations, the specification; industry recognised working practices, the working environment and the natural environment.

They will **know, understand and apply** the correct methods and procedures for the commissioning and handing over the electrical system and equipment including the:

- identification and use of the correct instruments
- completion of the relevant documentation
- recording of relevant data and information
- identification and consideration of the customer's need for electrical systems and equipment configuration
- planning of the resources required to carry out the commissioning process.

Learners **must** work safely in accordance with the Health and Safety at Work etc. Act and the Electricity at Work Regulations.

**Guidance:** Within this unit learners will follow the requirements of BS 7671, and IET Guidance Note 3 and will be able to carry out the inspection, testing and commissioning. They will be able to complete relevant documentation (e.g. an Electrical Installation Certificate and relating schedules (up to a 100 A supply).

This unit build upon the learner's knowledge of the fundamental inspections and de-energised testing methods and requirements for single phase circuits covered in unit 206. It will additionally help underpin unit 307.

## Knowledge and Understanding

### NOS outcome:

1. How to determine and obtain the resources required, as relevant, to undertake:
  - Initial inspection and testing
  - Periodic inspection and testing

### NOS outcome:

2. How to select the instruments to be used for carrying out relevant tests

### Scope and range:

- 2.1 Instruments test leads and accessories used for the range of tests in BS 7671 (and adhering to the requirements of GS 38)

### NOS outcome:

3. How to confirm that the test instruments are fit for purpose and have a current calibration certificate

### NOS outcome:

4. The methods and procedures for conducting a visual inspection on the enclosures for cables, conductors and wiring systems to confirm they are:
  - Located and secured correctly
  - Electrically and mechanically sound

### Scope and range:

- 4.1 To enable completion of the Schedule of Inspections (as shown in BS 7671: domestic and similar premises with up to 100 A supply).

### NOS outcome:

5. The methods and procedures for conducting a visual inspection on the electrical cable, conductor and wiring systems to confirm they are:
  - Located and secured correctly
  - Identified and/or labelled correctly

### Scope and range:

- 5.1 To enable completion of the Schedule of Inspections (as shown in BS 7671: domestic and similar premises with up to 100 A supply).

**NOS outcome:**

6. The methods and procedures for conducting a visual inspection on the equipment, accessories and components to confirm they are:
- Located and secured correctly
  - Identified and/or labelled correctly

**Scope and range:**

6.1 To enable completion of the Schedule of Inspections (as shown in BS 7671: domestic and similar premises with up to 100 A supply).

**NOS outcome:**

7. The industry practices and organisational procedures to ensure the co-ordination of site services and the activities of other trades affected by:
- The inspection process and procedures
  - The testing process and procedures

**NOS outcome:**

8. The correct procedures for safe isolation

**NOS outcome:**

9. The methods and processes to carry out correctly the tests that ensure safe and efficient operation of the electrical system

**NOS outcome:**

10. The organisational procedures for:
- Completion of the relevant documentation
  - The recording of relevant data and information
  - Informing relevant people
  - Addressing issues and problems identified

**NOS outcome:**

11. The resources required to undertake the commissioning process.

**NOS outcome:**

12. Methods, organisational procedures and systems to:
- Record and assess information
  - Ensure that the results are recorded in the appropriate
  - Information systems and passed to the relevant people

**NOS outcome:**

13. The correct methods and organisational procedures for implementing the commissioning process.

**NOS outcome:**

**14. Conditions that are suitable to implementation.**

**NOS outcome:**

**15. How to resolve any problems identified.**

**NOS outcome:**

**16. How to ensure that the electrical system and equipment is ready for hand over to the customer/client.**

**NOS outcome:**

**17. Methods for providing clear and accurate information to relevant people.**

**NOS outcome:**

**18. The organisational procedures for:**

- **Notifying relevant people of any variations**
- **Obtaining customer/client acceptance of the electrical system and equipment**
- **The completion of all relevant documentation**
- **Recording of information and/or data in the appropriate information systems**

**Delivery advice (depth of content)**

The emphasis in this unit is on initial verification of electrical installations however learners will gain knowledge complementary to periodic inspection and testing (e.g. in selecting and using test equipment).

Learners will understand the purpose and requirements for initial verification of electrical installations. Refer to BS 7671 and IET Guidance Note 3 (General requirements). Refer to the relevant information given in the chapter for initial verification. Refer to Section 511 - compliance with standards. The relevant documents associated with the inspection, testing and commissioning of an electrical installation: Electricity at Work Regulations, BS 7671, IET Guidance Note 3; HSE Guidance. The information that is required by the inspector to conduct the initial verification of an electrical installation: BS 7671 and IET Guidance Note 3. Refer to the relevant information given in the chapter for initial verification, Section 131, The general characteristics required by Sections 311 to 313, Information required by Regulation 514.9.1 (diagrams, charts, circuit schedules).

Learners will understand in this unit safe working and working in accordance with risk assessments / permits to work / method statements. The safe use of tools and equipment, safe and correct use of measuring instruments, the use of PPE and the reporting of unsafe situations (refer to the general requirements given in IET Guidance Note 3).

### **In particular:**

**3.** Cover the requirements for the safe use of instruments to be used for testing and commissioning, to include the Checks required to prove that test instruments are safe and functioning correctly. The requirements for test leads and probes must comply with HSE Guidance GS 38. The need for instruments to be regularly checked and calibrated.

### **4 - 6**

They will be able to identify the appropriate items to be checked during the inspection process for given situations and installations. Re-cap on the application of the human senses appropriate for initial verification, and how they are applied. The requirements for the inspection of electrical installations. Refer to the current edition of BS 7671: Refer to the relevant information given in the chapter for initial verification. Refer to IET Guidance Note 3. Typical examples to be covered. Requirements for the inspection e.g. earthing conductors, earth electrodes, circuit protective conductors, main and supplementary protective bonding conductors, devices for isolation and switching, type and rating of overcurrent protective devices, type and rating of RCDs and RCBOs, barriers and enclosures, containment systems (steel and plastic), cables, conductors and terminations, electrical accessories. Refer to the complete list of items in BS 7671, and GN3.

The requirements for the inspection of special installations and locations as identified in Part 7 of BS 7671 and IP Classification of equipment. Ensure appropriate coverage of the degrees of protection offered by electrical equipment enclosures and the requirements for given locations and environments (IP Code) BS EN 60529. Delivery of this aspect can also be linked to the requirements for barriers and enclosures during the inspection process.

### **8.**

**Safe Isolation:** the requirements of the Electricity at Work Regulations for the safe inspection of electrical systems and equipment. This will include the safety of: Those carrying out the work Those using the premises during the inspection. Refer to the relevant parts of the Electricity at Work Regulations 1989, and the Memorandum of guidance on the Electricity at Work Regulations 1989 (HSR25).

**Safe isolation procedure:** Carrying out safe working practices: Identification of circuit(s) to be isolated, identifying suitable points of isolation, Selecting correct test and proving instruments in accordance with relevant industry guidance and standards (GS 38), Selecting locking devices for securing isolation, Warning notices, Appropriate sequence for isolating circuits.

Implications of safe isolation. To cover how this relates to the safety of the inspector, other personnel, customers/clients and the public etc. Effects to building systems/circuits/electrical equipment due to the removal of the supply. Reiterate the implications of **not** carrying out safe isolation.

They will understand the implication of not using approved test equipment during safe isolation and that extra low voltage might not be detected. Highlight that 50 mA can be potentially lethal Safe isolation is carried out so that the point of isolation is always under the control of the appointed person.

9. The learner will understand the requirements for the safe testing and commissioning of electrical installations. The tests to be carried out on an electrical installation in accordance with the BS 7671 and IET Guidance Note 3. The appropriate instrument for each test to be carried out and identifying the correct scale or setting. Cover why it is necessary for test results to comply with standard values (for safety, and correct function). Inspector will need to confirm the results with the installation design criteria and/or BS7671 as appropriate. The actions to be taken in the event of unsatisfactory results being obtained. And that testing is carried out in the sequence specified in BS 7671 and IET Guidance Note 3 (principally for safety). Refer to the relevant information given in BS 7671. If any test indicates a failure to comply, that test and any preceding test, the results of which may have been influenced by the fault indicated, shall be repeated after the fault has been rectified.

Cover the requirements for testing before circuits are energized – focus on the more in-depth aspects to build upon the L2 inspection and testing unit. For example factors that affect resistance values, interpretation of results from a ring final circuit test, IR testing on three-phase circuits, polarity testing on three phase circuits. Follow the requirements of BS 7671 and IET Guidance Note 3.

Cover the requirements for testing **energised** installations covering: the procedures for confirming polarity of the incoming supply. The methods for measuring earth electrode resistance to include installations forming part of a TT system and generators and transformers. Earth fault loop paths and the methods for verifying protection by automatic disconnection of supply. The measurement of the external earth fault loop impedance ( $Z_e$ ) and the system earth fault loop impedance ( $Z_s$ ). Establishing  $Z_e$  by enquiry, calculation of the value of  $Z_s$  from given information, comparing measured  $Z_s$  values with the maximum tabulated figures as specified in BS 7671 including the application of the correction factor.

The requirements and methods for the measurement of prospective fault current for single and three-phase installations (calculation, measurement and enquiry). the suitability of protective devices for prospective fault currents.

The methods for testing the correct operation of residual current devices.

The reasons for and methods of verifying phase sequence. The need for functional testing, and the items which require functional testing.

## 10 - 18

Within these outcomes the learner will also know and understand the appropriate procedures for dealing with clients during the commissioning and certification process. Ensuring the safety of others during the work activities and the importance of keeping clients informed during the process. Labelling electrical circuits, systems and equipment that are still to be commissioned and providing clients with all the appropriate documentation upon work completion.

The learner will understand the purpose of certification and associated documentation, the information that must be contained on initial verification documentation and

the certification process for a completed installation. The responsibilities of different relevant personnel in relation to the completion of the certification process. The requirements for the recording and retention of completed initial verification documentation in accordance with BS 7671.

Refer to the model forms provided in BS 7671 and Guidance Note 3; and the notes on that reversal of the model forms. The date for the first periodic inspection and test is required to be considered and recommended by the original installation designer, as part of their design.

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## Performance Criteria

1. Carry out safe isolation procedures in accordance with regulatory requirements for electrical installations.
2. Ensure the health and safety of themselves and others within the work location during inspection, testing and commissioning.
3. Check the safety of electrical systems prior to the commencement of inspection, testing and commissioning.
4. Assess whether the safe system of work is appropriate to the work activity.
5. Carry out a visual inspection in accordance with the requirements of the installation specification, BS 7671 and IET Guidance Note 3.
6. Complete a schedule of inspections in accordance with BS 7671 and IET Guidance Note 3 making technical decisions.
7. Select the correct test instruments and their accessories for tests.
8. Carry out tests in accordance with the installation specification and BS 7671 and manufacturer's instructions:
  - continuity
  - insulation resistance
  - polarity
  - earth fault loop impedance/earth electrode
  - prospective fault current
  - RCD operation
  - functional testing.
9. Analyse and verify test results reporting all findings to relevant persons, as appropriate: *Cover One: (e.g. over the assessment occasions cover one item twice or both items once)*
  - Representatives of other services/colleagues
  - Customers/clients.
10. Complete in accordance with BS 7671 and IET Guidance Note 3:
  - an Electrical Installation Certificate (+ Schedule of Inspections and Schedule of Test Results)
  - a Minor Electrical Installation Works Certificate.
11. Complete the handover of electrical systems and equipment to relevant persons including the provision of accurate and complete documentation regarding the completed inspection, testing, commissioning and customer satisfaction.

12. **Demonstrate to the customer/client that the operation of the circuits, equipment and components are in accordance with the installation specification and customer/client requirements.**

DRAFT

## Unit Ref 307

## Identify and rectify faults in electrical systems and equipment

Level:	
GLH:	

### What is this unit about?

This unit covers the **understanding and performance requirements** for the diagnosis and rectification of faults in electrical systems and equipment.

The learner must be able to carry out the processes and procedures for the identification and rectification of faults in accordance with the current versions of the appropriate industry standards and regulations, the specification, industry recognised working practices, the working environment and the natural environment. They must understand and apply the correct methods and procedures when identifying and rectifying faults in electrical systems and equipment, including:

- the identification and use of the correct instruments
- how to identify and locate faults
- how to rectify the faults that are identified, located and diagnosed
- the completion of the relevant documentation
- the recording of relevant data and information.

Learners **must** work safely in accordance with the Health and Safety at Work etc. Act and the Electricity at Work Regulations

**Guidance:** Within this unit learners will follow the requirements of BS 7671, and IET Guidance Note-3. This unit relates to all units in the qualification, in particular unit 306.

## **Knowledge and Understanding**

1. How to obtain clear and detailed information about the reported fault(s) and any components which need to be replaced from:
  - Relevant sources of information
  - Relevant documentation
2. The organisational procedures and industry practices when carrying out the processes for the identification and rectification of faults for:
  - Advising the relevant people about the potential disruption and consequences.
  - Confirming a programme of work with the relevant people.
  - Ensuring the coordination of site services and the activities of other trades affected
3. How to determine and obtain the resources required, as relevant, to undertake:
  - The identification and location of the fault(s)
  - The rectification of the fault(s)
4. How to select the instruments to be used
5. How to confirm that the instruments are fit for purpose and have a current calibration certificate
6. The techniques to identify, locate, diagnose and rectify faults
7. How to repair, remove and replace in accordance with industry practices:
  - Electrical cables, conductors and/or wiring system
  - Equipment, accessories and components
8. How to ensure, if the fault(s) cannot be corrected immediately, the safety of the relevant:
  - Electrical cables, conductors and/or wiring system
  - Equipment, accessories and components
9. The methods and processes to inspect and test, as appropriate and in accordance with industry practices, the repaired and/or replaced:
  - Electrical cables, conductors and/or wiring system
  - Equipment, accessories and components

**10. How to provide clear and accurate information to relevant people about the electrical system and equipment in terms of:**

- **Hand over to the customer/client.**
- **Any variations to the original system and/or its equipment**
- **Customer/client acceptance of the completed work in accordance with organisational procedures**
- **Relevant documentation being completed and recorded in the appropriate information systems in accordance with organisational procedures**

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## **Delivery advice (depth of content)**

**1** Learners will understand the documentation and information relevant to fault diagnosis, such as: BS 7671, certificates/reports, installation specifications, drawings/diagrams, manufacturer's information and operating instructions, maintenance records.

Manufacturers data and previous test results can be used to track deterioration and assess the effectiveness of maintenance checks. Speaking to the customer/client in relation to understanding the characteristics and nature of the fault.

**2** Learners will understand the implications of the fault diagnosis for customers and clients and the communication requirements relevant to fault diagnosis. The implications of fault diagnosis through loss of circuits and equipment use. The communication requirements such as informing relevant persons about information on electrical fault diagnosis and correction work. Why it is important to provide relevant persons with information on fault diagnosis and correction work clearly, courteously and accurately. Why relevant people need to be kept informed during completion of fault correction work (other workers/colleagues, customers/clients and representatives of other services).

**3-5** Learners will understand the resources required for fault diagnosis. The appropriate test instrument/s for fault diagnosis work includes: Voltage indicator, Low resistance ohm meter, Insulation resistance testers, EFZ and PFC tester, RCD tester, Tong tester/clamp on ammeter, Phase sequence tester.

They will understand how test instruments are confirmed to be fit for purpose and functioning correctly (recap as necessary from the inspection and testing unit). Compliance with GS 38.

**6 - 9** Learners will understand the appropriate and logical procedures for carrying out fault diagnosis tests such as six-point, half-split, input to output, cause and effect, substitution of parts. They will understand how to analyse and determine if test results are acceptable and the dangers of electricity in relation to fault diagnosis work, and the health and safety requirements relevant to diagnosing and correcting electrical faults in electrical systems and equipment.

Health and safety requirements include:

- Working in accordance with risk assessments / permits to work/method statements
- Safe use of tools and equipment
- Safe and correct use of measuring instruments
- Provision and use of PPE
- Reporting of unsafe situations.
- Safe working procedures:
- Effective communication with others. I.e. people on the premises, customers etc.
- Use of barriers
- Positioning of notices
- Safe isolation
- Use of equipment to GS 38.

Learners will be able to Identify types, causes and consequences of electrical faults such as:

- Loss of supply
- Low voltage/voltage drop
- Component/equipment malfunction/failure
- Operation of overload or fault current devices
- Arcing - loose connection
- High resistance - e.g. loose connection etc.
- Transient voltages - lightning strike
- Excess current - overload
- Insulation failure - deterioration, mechanical damage
- Short-circuit, Open Circuit and Earth fault.
- Signal faults.
- Inherent faults – faults that occur through poor design and incorrect termination (cross connections)

They will understand typical types of faults and their likely locations in wiring systems and equipment. Locations in wiring systems, terminations and connections, equipment/accessories (switches, luminaires, switchgear and control equipment), Instrumentation/metering.

The precautions that must be taken when carrying out fault diagnosis with regard to particular locations, equipment and circumstances. Such as: lone working, hazardous areas, fibre-optic cabling, electro-static discharge (friction, induction, separation), electronic devices (damage by over voltage), IT equipment (e.g. shutdown, damage), high frequency or capacitive circuits, presence of batteries (e.g. Lead acid cells, connecting cells), additional sources of energy (e.g. solar panels, UPS); time controlled devices (e.g. time controlled circuits).

They will understand the logical stages of fault diagnosis. identification of symptoms, collection and analysis of data, use of sources/types of information, checking and testing (e.g. supply, protective devices), interpreting results/information, fault correction, functional testing, restoration

The factors which can affect repair or replacement of equipment. Such as: cost, availability of replacement parts, resources and staff, down time (planning), legal and personal responsibility (e.g. contracts, warranties, relevant personnel), gaining access to systems and equipment, provision of emergency or stand by supplies; client demand (continuous supply, out of hours working).

The procedures for verifying that the fault has been corrected suitable for the situation using technical analysis such as: functional testing/checking. Testing for: continuity, insulation resistance, polarity, earth fault loop impedance, RCD operation, current and voltage measurement/ checking presence of supply; phase sequencing.

The methods to ensure the safe disposal of any waste and that the work area is left in a safe and clean condition.

**10.** Learners will understand how to provide clear and accurate information to relevant people about the fault and subsequent outcomes.

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## Performance Criteria

1. Check it is safe to carry out fault diagnosis.
2. Inform the relevant personnel of the fault diagnosis work (such as personnel on the premises, users of electrical equipment).
3. Carry out the safe isolation procedure.
4. Evaluate and apply appropriate methods to ensure the safety of themselves and others when diagnosing and correcting electrical faults.
5. Communicate effectively with relevant personnel (e.g. customer, premises manager) to ascertain the nature of the fault.
6. Select and interpret appropriate documents (e.g. lay-out drawings, schematic diagrams etc) which relate to the electrical systems and equipment being worked upon.
7. Assess and communicate potential disruption that may be a consequence of fault diagnosis and correction work to relevant people (such as other workers/colleagues Customers/clients).
8. Carry out relevant inspections of electrical equipment analysing findings.
9. Confirm test instruments are fit for purpose, functioning correctly and are correctly calibrated.
10. Perform suitable diagnostic tests, based on engineering decision, to identify electrical faults:  
Cover Three:
  - loss of supply
  - overload
  - short-circuit
  - earth fault
  - incorrect phase rotation
  - high resistance joints/loose terminations
  - component, accessory or equipment faults
  - open circuit
  - signal faults.
11. Use appropriate methods for locating faults including:
  - using a logical approach
  - using safe working practices
  - interpretation of test readings.

12. Use appropriate instruments correctly to carry out fault diagnosis: Cover Three:
  - voltage indicator
  - low resistance ohm meter
  - insulation resistance tester
  - EFLI and PFC tester
  - RCD tester
  - ammeter
  - phase rotation tester
  - other appropriate instrument.
13. Assess the appropriate repairs, removals and replacements and their implications with relevant people. Cover One: (e.g. over the assessment occasions cover one item twice or both items once)
  - other workers/colleagues
  - customers/clients.
14. Perform fault correction procedures correctly and safely using appropriate tools, equipment and material.
15. Assess and verify that replacement components and associated equipment maintain:
  - ease of access to enable future maintenance
  - compliance with relevant regulations
  - compliance with manufacturer's instructions/ organisational procedures.
16. Apply appropriate procedures to ensure electrical equipment and components are left safe, in accordance with industry regulations, if the fault cannot be corrected immediately based on technical assessment.
17. Establish and perform an appropriate inspection and testing procedure to confirm that circuits/equipment/ components are functioning correctly after completion of fault correction work.
18. Record test results and other appropriate information regarding the fault correction work clearly and accurately and report it to relevant people: Cover One: (e.g. over the assessment occasions cover one item twice or two different items once)
  - other workers/colleagues
  - customers/clients
  - representatives of other services.

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**GLH:** 

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**What is this unit about?**

This unit is designed to enable learners to understand the relationship between electrical scientific principles and the competencies required of a qualified electrical operative. Its content is the knowledge needed by a learner to underpin the application of skills in the installation of electrical systems and equipment.

This unit is about covers the understanding of other supplies, properties of electrical circuits and components, D.C. machines and A.C. motors, electrical lighting systems, electrical heating, and basic electronics.

This unit is assessed by its own onscreen examination (closed book).

## Knowledge and Understanding

### Learning outcome:

#### 1. Understand renewable and other sources of electricity

##### Criteria

##### 2.1 The basic operating principles of **renewable sources of electricity**

**Range:** solar power (thermal and photovoltaic), wind energy, wave energy, micro hydro.

##### 2.2 The basic operating principles of combined heat and power (CHP) including micro CHP.

##### 2.3 The basic operating principles of **other sources of electricity**

**Range:** batteries, cells, UPS systems.

##### 2.4 Smart metering.

**Range:** the advantages and limitations of electricity smart meters.

#### Delivery advice (depth of content)

Learners will understand the main operating principles and characteristics of renewable electrical supplies.

They will understand the benefits of micro-generation being:

- cutting carbon dioxide emissions
- does not deplete the earth's resources and is a clean fuel
- delivering energy to off the grid locations
- security of supply
- overall energy costs can be vastly reduced
- energy generation efficiency is improved as more than 90% of the fuel is converted to energy, as opposed to traditional power stations which can waste over half of the fuel in transportation before it even reaches the consumer
- less likely to be affected by energy price fluctuations
- combats climate change
- employment opportunities will be created as the industry grows
- promotes energy diversity in a competitive market.

Learners will understand how electricity is generated by reusing heat (CHP and micro CHP).

The operating principles of batteries and cells, and how energy can be stored – including home storage systems. Capacity and amp-hour calculation. Primary and secondary batteries. Cell types. Storage of batteries. Charging (and overcharging) of batteries. Self-discharge.

Learners will have an understanding of a UPS. Operation and typical applications of a UPS.

Learners will have an understanding of the advantages and limitations of electricity smart meters – such as: no need to submit meter readings, accurate bills, raises awareness of energy consumption, selection of good tariffs on offer.

First generation smart meter limitations such as can become dumb if switching supplier, inaccurate display, and signal problems.

Issues due to micro generation and smart metering (however the technology and infrastructure is constantly improving).

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## Learning outcome:

### 2. Understand the properties of electrical circuits and components

#### Criteria

2.1 The appropriate **mathematical principles** which are relevant to electrical work tasks

**Range:** statistics, the trigonometry of right-angled triangles, Pythagorean theorem.

2.2 **Quantities** relevant to electrical work

**Range:** impedance, inductance, inductive reactance, capacitance, capacitive reactance, power factor.

2.3 The relationship between resistance, inductance, capacitance and impedance.

2.4 Calculation of **electrical quantities** in alternating current circuits

**Range:** Resistance, inductance, inductive reactance, capacitance, capacitive reactance, and impedance

2.5 Operating principles of **electro-mechanical components**

**Range:** contactors, relays, and solenoids.

2.6 Types of transformers.

2.7 The operating principles, applications and limitations of transformers

**Range:** Iron loss, copper loss, relationship between current and voltage, primary and secondary windings, step up and step-down transformers, primary and secondary voltages, primary and secondary current, kVA rating.

2.8 The relationship between kW, kVA, kVA and power factor.

2.9 Power factor improvement.

2.10 Voltage and current in star and delta connected systems.

2.11 Advantages of balanced star connected systems.

2.12 The neutral current in a three-phase star connected system.

#### Delivery advice (depth of content)

Learners will understand the trigonometry of right-angled triangles and Pythagorean theorem to enable them to carry out calculations involved with alternating current theory and reactive loads. They will be able to utilise basic statistics.

Learners will understand alternating current quantities and relating components (inductors capacitors and resistors the relationship between alternating current quantities (and resistance). The action of these components in alternating current circuits.

They will be able to construct phasor diagrams and understand the resistance, power and voltage triangle. They will be able to calculate inductance, capacitance, impedance, inductive reactance, and inductive capacitance. They will be able to calculate power quantities in single and three phase circuits (kVA, kVAR, and kW). They will understand R,L,C circuits and their relevance to electrical installations. They will understand power factor and power factor improvement. they will be able to determine the value of capacitance required to improve power factor to a given value. calculation of power factor and the methods of power factor correction.

They will understand the operating principles of electro-mechanical components. Learners will be able to describe the action of these components and how they are applied for circuit control. Learners will recognise relays and solenoids, the types of contacts (N/O and N/C). (Explored further in the next learning outcome).

Learners will appreciate the kVA rating of a transformer. The limitations of transformers and the different losses in transformers. Learners will understand the operating principles of transformers. Step up and step-down and isolating. transformers. Primary and secondary windings. relationship between current and voltage. They will be able to determine by calculation the primary and secondary voltages, primary and secondary current, and primary and secondary turns. Turns ratio. Identify transformer types such as: potential transformer, current transformer and isolating transformer. Auto transformers.

Learners will be able to calculate values of voltage and current in star and delta connected systems. And will recognise the advantages of having balanced star connected systems. They will be able to determine using a phasor diagram the value of neutral current in an unbalanced star system. A fundamental knowledge of harmonic currents and their implications to electrical installations.

**Learning outcome:**

**3. Understand the operating principles and applications of D.C. machines and A.C. motors**

**Criteria**

3.1 The basic types, applications and describe the operating principles of D.C machines

3.2 The operating principles of A.C motors

3.3 State the basic types, applications and limitations of A.C motors

3.4 The basic operating principles, limitations and applications of motor control

**Delivery advice (depth of content)**

For this learning outcome learners will understand the operating principles and applications of DC machines: series, shunt, and compound.

A.C motors will cover: Single phase A.C motors: induction, capacitor start, split phase, universal, synchronous). Range Three phase A.C. motors: induction and wound-rotor.

They will be able to recognise and draw simple circuit diagrams to show the arrangements of the motor and the key components. They will be able to perform calculations In relation to DC machines and AC Motors. They will understand some of the common techniques used to control motors: direct-on-line, star-delta, rotor-resistance, soft-start, variable frequency. They will understand motor control operating principles applications and limitations.

### Learning outcome:

## 4. Understand the principles and applications of electrical lighting systems

### Criteria

4.1 The basic principles and applications of illumination

4.2 The operating principles, types, limitations and applications of luminaires

#### Delivery advice (depth of content)

For this learning outcome learners will be able to perform lighting calculations: inverse square law, cosine law, and the lumen method.

They will understand the operating principles, limitations and applications of different types of luminaires:

##### **General Lighting Service (GLS):**

- Tungsten
- Halogen

##### **Discharge lighting:**

- Low and high pressure mercury vapour
- Low and high pressure sodium vapour
- Metal halide

##### **Energy saving:**

- Compact fluorescent lamps
- LED.

They also gain an appreciation of lighting protocols such as Digital Addressable Lighting Interface (DALI). This can be linked to unit 304.

Link back to unit 204 in relation to smart and wireless controls.

**Learning outcome:**

**5. Understand the principles and applications of electrical heating**

**Criteria**

5.1 The basic principles of electrical space heating and electrical water heating.

5.2 The operating principles, types, limitations and applications of electrical space and water heating appliances and components.

**Delivery advice (depth of content)**

For this outcome learners will understand the basic principles of electrical space heating and electrical water heating covering convection cycle conduction, and radiation.

They will understand the following appliances and components: immersion heaters, storage heaters, convector heaters, under floor heating, controls, timers and programmers for heating systems (S plan, Y plan, S plan plus).

Link back to unit 304 in relation to smart and wireless controls.

## Knowledge and Understanding

### Learning outcome:

#### 6. Know the types, applications and limitations of electronic components in electrical systems and equipment.

##### 6.1 The basic operating principles of **electronic components and devices**

**Range:** capacitors, resistors, rectifiers, diodes (including Zener, LED and photo); thermistors, diacs, triacs, transistors, thyristors, invertors.

##### 6.2 The function and application of electronic components that are used in **electrical systems**

**Range:** security alarms, telephones, dimmer switches, heating/boiler controls, motor control, wireless control systems, solar PV systems.

### Delivery advice (depth of content)

Learners will be able to identify the electronic components and devices listed, both from circuit symbols and physical appearance. They will understand the basic operating principles of these electronic components and devices. (The rectifier is the device). Cover (where relevant) the markings and colour-coding of components/devices, including where relevant their polarity. Highlight safety considerations from potential latent energy stored in capacitors.

They will then be able to recognise how these electronic components and devices are utilised within electrical systems.

Note that this outcome will have synergy with unit 204 in the application of LED lighting and dimmer switches.