SQA Advanced Unit Specification: general information for centres

Unit title: Electrical Installation Design

Unit code: HV5X 48

Superclass: TH

Publication date: November 2017

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This unit has been designed to allow candidates to develop the skills required to design electrical installation circuits to comply with the wiring regulations **current** BS 7671. It also allows candidates to develop the necessary knowledge and understanding of the factors to be considered when selecting the correct cable and size for a chosen situation. In addition, the unit is also designed to develop a technical knowledge and understanding of overcurrent protection and earth leakage protection methods for electrical installations plus various earthing systems and their characteristics.

On completion of the unit the candidate should be able to:

1 analyse the overcurrent protection arrangements of circuits in an electrical installation
2 analyse the earthing requirements of electrical installations in compliance with **current** BS 7671
3 analyse cable sizing for given circuit conditions in an electrical installation in compliance with **current** BS 7671
4 execute a design exercise for an electrical installation in compliance with **current** BS 7671

Recommended prior knowledge and skills

Candidates should have a broad knowledge and understanding of the design of electrical power-distribution systems, the installation of electrical-wiring systems, apparatus and cabling and the testing of electrical installations. This may be evidenced by possession of Electrical Installation units from the National Certificate(s) in Electrical Engineering. However, entry requirements are at the discretion of the centre.

Credit points and level

1 SQA Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates.*

Core Skills

Achievement of this unit gives automatic certification of the following:

Complete Core Skills None

Core Skill component Critical Thinking at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the support notes of this unit specification.

Context for delivery

This unit was developed for the SQA Advanced Certificate and SQA Advanced Diploma in Electrical Engineering. If this unit is delivered as part of a group award, it is recommended that it should be taught and assessed within the subject area of the group award to which it contributes.

Assessment

The assessment for Outcomes 1, 2 and 3 of this unit should be combined together into one written assessment paper. This paper should be taken by candidates at one single assessment event that should last two hours. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions. This assessment should be conducted under controlled, supervised conditions.

It should be noted that candidates must achieve all the minimum evidence specified for each outcome in order to pass the unit.

The assessment for Outcome 4 of this unit should take the form of a project-based installation design assignment in which candidates are provided with a specification for part of the electrical installation of a small manufacturing facility. The installation should contain the following:

- one single-phase motor circuit
- one three-phase motor circuit
- one general lighting circuit using discharge luminaries

Candidates will be expected to design an appropriate electrical installation for given environmental and loading conditions.

This assignment draws together the design concepts developed in Outcomes 1–3 and should be developed during delivery of the unit content.

It should be noted that candidates must achieve all the minimum evidence specified for each outcome in order to pass the unit.

NOTE: IT software packages must NOT be used during the assessment of this unit.

The sections of the unit stating the outcomes, knowledge and/or skills, and evidence requirements are mandatory.

SQA Advanced Unit Specification: statement of standards

Unit title: Electrical Installation Design

Unit code: HV5X 48

The sections of the unit stating the outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Analyse the overcurrent protection arrangements of circuits in an electrical installation.

Knowledge and/or skills

- Definition of overcurrent, overload and short circuit current
- Typical causes and dangers associated with overcurrent
- Operation and characteristics of overcurrent protection devices
- Recognition of devices by BS and EN numbers
- Terms: current rating, fusing/tripping current, fusing/tripping factor, breaking capacity
- Selection of suitable devices for protection against possible overload and short circuit current

Outcome 2

Analyse the earthing requirements of electrical installations in compliance with **current** BS 7671.

Knowledge and/or skills

- Typical causes and dangers of protective conductor current and earth fault currents
- An appreciation of ‘basic protection and fault protection’
- Methods used for protection against electric shock due to single-fault conditions
- Types of system earthing for one of the following: TN, TN-C, TN-S, TN-C-S
- Requirements of the earth fault loop impedance in relation to the electric shock constraints of a circuit
- The relationship between the protective device, the earth fault loop impedance and disconnection time of the protective device
- Requirements of the circuit protective conductor cross-sectional area in relation to the thermal constraints of a circuit
- Construction and operation of residual current device (RCD)
- Identification of the various protective conductors

Outcome 3

Analyse cable sizing for given circuit conditions in an electrical installation in compliance with **current** BS 7671.

Knowledge and/or skills

- Relationship between the circuit design current, the nominal current rating/setting of the protective device and the required current capacity of the circuit conductors
- Types and nominal ratings of the protective devices
- Co-ordination of the requirements between conductors and protective devices
- Determination of correction factors for an electrical installation
- Relationship between correction factors for a given circuit and the required current capacity of its conductors
- Use of **current** BS 7671 in the selection of an appropriate cable for a given application
- Relationship between the cable size resulting from the cumulative effects of cable correction factors, voltage drop, shock protection and thermal constraints, and the design current of the circuit.

Outcome 4

Execute a design exercise for an electrical installation in compliance with **current** BS 7671.

Knowledge and/or skills

- Assessment of electrical installation and supply requirements
- Selection of types of cable and methods of installation and justification of cable types and installation methods in respect of environmental, economic and other relevant factors
- Production of cable route diagrams
- Determination of earth fault loop impedance and prospective fault current
- Identification of appropriate protective devices
- Determination of earthing arrangements
- Calculation of conductor cross-sectional area and type of cable required for given circuits in accordance with correction factors, volt-drop, electric shock and thermal constraints
- Selection of appropriate distribution switchgear in accordance with the requirements of **current** BS 7671
- Production of illustrations (sketches) to show the methods of installation used

Evidence requirements for Outcomes 1, 2 and 3

Evidence for the knowledge and/or skills of Outcomes 1, 2 and 3 will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment, **four out of six** knowledge and/or skills items for Outcome 1 and **five out of nine** knowledge and/or skill items for Outcome 2 and **four out of seven** knowledge/skill items for Outcome 3 should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of four out of six, five out of nine and four out of seven knowledge and/or skills items is required each time the unit is assessed. Candidates must provide a satisfactory response to all items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

Outcome 1

- define types of overcurrent ie overload and short circuit current
- analyse typical causes and dangers associated with overcurrent
- analyse the operation and characteristics of overcurrent protection device
- identify overcurrent protection devices by their BS and EN numbers
- define terms related to overcurrent protection devices ie current rating fusing/tripping current; fusing/tripping factor; breaking capacity
- select suitable devices for protection against given overload and short circuit current conditions

Outcome 2

- analyse typical causes and dangers of protective conductor current and earth fault current
- define the terms 'basic protection' and 'fault protection'
- analyse the methods used for protection against electric shock due to single-fault conditions
- describe the types of system earthing for one of the following: TN, TN-C, TN-S, TN-C-S
- analyse the requirements of the earth fault loop impedance in relation to the electric shock constraints of a circuit
- analyse the relationship between protective device, the earth fault loop impedance and disconnection time of the protective device
- analyse the requirements of the circuit protective conductor cross-sectional area in relation to the thermal constraints of a circuit
- describe the construction and operation of a residual current device (RCD)
- identify the various protective conductors of an electrical installation

Outcome 3

- Analyse the relationship between the circuit design current, the nominal current rating/setting of the protective device and the required current capacity of the circuit conductors
- Identify types and nominal ratings of the protective devices
- Analyse the co-ordination of the requirements between conductors and protective devices
- Determine the correction factors for an electrical installation
- Analyse the relationship between correction factors for a given circuit and the required current capacity of its conductors
- Explain the use of **current** BS 7671 in the selection of an appropriate cable for a given application
- Analyse the relationship between the cable size resulting from the cumulative effects of cable correction factors, voltage drop, shock protection and thermal constraints, and the design current of the circuit

Assessment guidelines for Outcomes 1, 2 and 3

The assessment for Outcomes 1, 2 and 3 should be combined together to form one assessment paper. This single assessment paper should be taken at a single assessment event lasting two hours and carried out under supervised, controlled conditions. Such a paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

Relevant documentation including a copy of **current** BS 7671 and the IEE On-Site Guide should be provided for this assessment. No other course notes documentation should be permitted.

This assessment should be taken after the delivery of Outcome 3.

Evidence requirements for Outcome 4

Candidates will be given an assignment to design an electrical installation for part of a small manufacturing facility. The candidates will be provided with a specification for part of the electrical installation for this small manufacturing facility.

The specification will include a plan of the manufacturing facility showing the location of the outlet points for:

- one single-phase motor circuit
- one three-phase motor circuit
- one general lighting circuit using discharge luminaires

The specification will also include loading details for the outlet points and other factors, including environmental conditions, which apply to the installation.

Candidates will be expected to design an appropriate electrical installation for these environmental and loading conditions using the design analysis developed in Outcomes 1–3.

Candidates will be required to produce evidence in the form of a written report (700–800 words plus diagrams, appendices) to demonstrate their knowledge and/or skills to design an electrical installation to encompass the following:

- assess the electrical installation and supply requirements
- select appropriate types of cable and methods of installation and justify the cable types and installation methods chosen in respect of environmental, economic and other relevant factors
- produce diagrams to show all cable routes
- determine the earth fault loop impedance and prospective fault current
- identify the most appropriate protective devices
- determine the earthing arrangements
- calculate the conductor cross-sectional area and type of cable required for given circuits in accordance with correction factors, volt-drop, electric shock and thermal constraints
- select the most appropriate distribution switchgear in accordance with the requirements of **current** BS 7671
- produce illustrations (sketches) to show the methods of installation used.

NOTE: IT software packages must NOT be used during this assessment.

Assessment guidelines for Outcome 4

Candidates will be provided with a copy of **current** BS 7671 and the 'IEE On-Site Guide' for use during the design assignment.

Centres should make every reasonable effort to ensure the report is the candidate's own work. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter. A checklist should be used to record evidence of the candidate's knowledge and understanding

SQA Advanced Unit specification: support notes

Unit title: Electrical Installation Design

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this unit

This unit has been written in order to allow candidates to develop their knowledge and competence in the following areas:

1 analyse the overcurrent protection arrangements of circuits in an electrical installation
2 analyse the earthing requirements of electrical installations in compliance with **current** BS 7671
3 analyse cable sizing for given circuit conditions in an electrical installation in compliance with **current** BS 7671
4 execute a design exercise for an electrical installation in compliance with **current** BS 7671

The unit has been developed within the mandatory section of the SQA Advanced Diploma in Electrical Engineering. The unit is intended to be delivered in conjunction with the SQA Advanced Units: *Electricity Power Systems, Application of Electrical and Electronic Instruments, Electrical Safety* and *Electrical Installation Skills*.

1 Analyse the overcurrent protection arrangements of circuits in an electrical installation. (8 hours)

This outcome in intended to outline the operational features of overcurrent protective devices and to highlight their characteristics. The intention is to provide sufficient information to allow specific devices to be chosen for given overcurrent situations.

- Definition of overcurrent, ie overload current and short circuit current
- Typical causes and dangers associated with overcurrent:
  - risk of overheating of cables
  - risk of fire
  - risk of electric shock due to deterioration of insulation
  - risk of burns
- Operation of overcurrent protective devices:
  - ie semi-enclosed fuses
  - cartridge fuses (including HBC fuses)
  - thermal and magnetic trips
  - miniature circuit breakers
- Characteristics of overload protection devices:
  - thermal and magnetic trips
  - miniature circuit breakers
  - fuses

- Recognition of devices by BS and EN numbers:
  - Semi-enclosed or re-wireable fuse — BS 3036
  - Cartridge fuse — BS 1361
  - High Breaking Capacity fuses (HBC) — BS 88-2.1 and BS 88-6
  - Type B, C and D Circuit Breakers
  - and RCBOs — BS EN 60898 and BS EN 61009
- Definition of overcurrent terms:
  - current rating
  - fusing/tripping current
  - fusing/tripping factor
  - breaking capacity
- Selection of suitable devices for protection against possible overload and short circuit current

2 Analyse the earthing requirements of electrical installations in compliance with current BS 7671 (10 hours)

- Definition of the terms ‘protective conductor current’ and ‘earth fault current’, in accordance with **current** BS 7671
- Definition of the terms ‘exposed conductive parts’ and ‘extraneous conductive parts’ in accordance with **current** BS 7671
- Appreciation of ‘basic protection and fault protection’
- Used for meeting the requirement for fault protection
- Description of the effects of protective conductor currents and earth fault currents on the user, the electrical installation and the premises in which the circuit is installed
- Construction and operation of residual current protective devices
- Identification of the of the ‘earth fault loop’ of a given installation
- The requirements of the earth fault loop impedance Zs in relation to the electric shock constraints of a circuit [Zs = Ze + (R1+R2)]
- Selection of disconnection times for different installations
- Identification of protective conductors:
  - Circuit protective conductor
  - Main equipotential bonding conductor
  - Earthing conductor
  - Supplementary equipotential bonding conductor
- Identification of Installation system earthing for one of the following: TN, TN-C, TN-S, TN-C-S
- The requirements of the minimum cross-sectional area of protective conductors in accordance with **current** BS 7671
- Identification of the types of protective conductor in accordance with **current** BS 7671
- Requirements for the selection of a minimum size and type of circuit protective conductor for given circuit loading conditions protective device and determination of the resulting earth loop impedance value
- Requirements to verify that the resulting earthing arrangement meet the thermal constraint requirements of current BS 7671. $S = \frac{\sqrt{I^2 t}}{k}$
- The need to re-selection the CPC if necessary
- Appreciation of the requirements for equipotential bonding in accordance with current BS 7671

3 Analyse cable sizing for given circuit conditions in an electrical installation in compliance with current BS 7671 (10 hours)

- Factors for the determination of the circuit design current (Ib) for given load conditions
- Determination of the nominal current rating (In) and type of protective device for given loads
- Appreciation of the need for correction factors in selecting a cable size
- Use of correction factors for ambient temperature, grouping, thermal insulation and types of overcurrent protective devices in relation to circuit installation considerations
- Relationship between the effective current carrying capacity (Iz) of required conductor and the correction factors for a given installation
- Determination of a suitable cable size (IT) allowing for external influences and correction factors, types of cable incorporating copper and aluminium, method of installation **current** BS 7671, type of insulation, classification of external influences, environmental conditions of cables and conductors
- Identification of the external influences which affect the choice of wiring system
- Determination of the appropriate method of installation
- Factors for the selection of appropriate type of cable for given situations
- Use of voltage drop tables to determine the voltage drop condition of chosen cable size and type, given loading conditions and length of cable run
- Appreciation of the factors which affect voltage drop in a cable and the possible effects of voltage and power loss in a cable under load conditions
- Factors for the selection of a suitable cable size in accordance with **current** BS 7671 allowing for all circuit constraints ie design current, protective device rating, correction factors, cable capacity required, voltage drop constraints, electric shock constrains, thermal constraints.

4 Execute a design exercise for an electrical installation in compliance with current BS 7671 (12 hours)

The assessment of this outcome is by means of a project which brings together the analysis of electrical installation design considered in Outcomes 1–3.

The content of Outcome 4 is therefore the application of the previous outcomes in an integrated form with additional design features included:

- Determination that the nature of the supply is appropriate for an electrical installation
- Determination of the type and rating of overcurrent protective devices for given circuit loadings of an electrical installation
- Determination of the earth fault loop impedance and prospective fault current of a given electrical installation
- Calculation of the maximum demand current of the electrical installation
- Determination that the required maximum demand current is appropriate for the supply
- Selection of switchgear/distribution appropriate to the electrical installation
- Selection of cables types appropriate for given installation conditions
- Calculation the design current of circuits for given load conditions
- Determination of the appropriate correction factors for a given circuit installation conditions
- Calculation of the cable volt drops for the given circuits
- Calculation of the earth loop impedance (Zs) of the circuits using the equation
- $Zs = Ze + (R_1+R_2)$

- Calculation of the circuit fault current
- Calculation of the circuit thermal constraints
- Justification of the chosen wiring/distribution system for a given electrical installation
- Production of a detailed drawing of the intended cable routes
- Production of detailed sketches of the intended cable installation methods

Guidance on the delivery and assessment of this unit

The delivery of this unit should be candidate-centred with the emphasis placed on the requirements of the assignment project.

Candidates will be required to understand the terminology used in electrical installation design and the reasons behind the design concepts being delivered. This requires the candidate to gain a high level of familiarity of the context in which the installation design requirements are being developed and the specific conditions in which they are being applied.

The assessment of the unit should provide the candidate with opportunities to develop his/her understanding of the installation design from the initial assessment of supply characteristics to the final presentation of the installation design documentation.

Since the component of Critical Thinking at SCQF Level 6 is embedded in this unit, it is strongly recommended that you follow the assessment guidelines given. If you wish to use a different assessment model, you should seek prior verification of the assessment instrument(s) you intend to use to ensure that the core skill is still covered.

Open learning

This unit may be delivered by distance learning however, which may incorporate some degree of online support. However, with regard to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangement would be required to be put in place to ensure that the assessments are conducted under controlled, supervised conditions.

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the evidence requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

Opportunities for developing Core Skills

In this unit candidates will develop skills in designing electrical installation circuits to comply with the current wiring regulations.

Candidates will:

- assess the electrical installation and supply requirements for a given specification
- select appropriate types of cable and methods of installation taking account of relevant factors including overcurrent and earthing requirements
- identify the most appropriate protective devices
- calculate the conductor cross-sectional area and type of cable required for given circuits in accordance with correction factors, volt-drop, electric shock and thermal constraints
- produce illustrations (sketches) to show the methods of installation used and an explanation to justify selection

This unit has the Problem Solving component of Critical Thinking embedded in it. This means that when candidates achieve the unit, their Core Skills profile will also be updated to show they have achieved Critical Thinking at SCQF level 6. In addition, candidates will be developing aspects of the Core Skills in Numeracy and Communication.

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.

History of changes to unit

Version	Description of change	Date

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

For further information, please call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

General information for candidates

Unit title: Electrical Installation Design

This unit has been designed to provide you with an opportunity to develop your knowledge and understanding of the design of electrical installations. If you already have some working knowledge of electrical installations, some of these design concepts may be familiar to you. If, on the other hand, this is your first contact with electrical installations and their design, the unit should provide you with an understanding of the design methods and their relationship to the relevant British Standard, **current** BS 7671.

A key factor in any unit related to the use of electrical energy is SAFETY and this emphasised in the design of an electrical installation. The design of an electrical installation must provide for the safety of the persons using the electrical equipment in the facility and must also protect the facility itself against the risk of fire. In order to achieve this, the Wiring Regulations **current** (BS 7671) set out various requirements relating to the methods of installation of cables, conductors and equipment and to the protection of circuits against overheating should faults occur. An important addition to this is also the protection of persons against the risk of electric shock.

Outcome 1 deals at length with the terminology used in relation to overcurrent protection and an analysis of the devices used to protect circuits against currents above the expected value for that circuit. It considers the factors to be taken into account when choosing the most appropriate overcurrent protection device.

Outcome 2 considers the requirements for earthing the installation as one method of reducing the risk to persons of electric shock. It outlines the requirements of **current** BS 7671 in relation to an analysis of shock prevention and considers how this is achieved in practice.

Outcome 3 analyses the factors to be considered when selecting cables for given load and environmental conditions. The cable must have a sufficient cross-sectional area to carry the circuit current and the type of cable and its method of installation must be such that it will not suffer damage or degradation during its normal lifetime. The requirements of **current** BS 7671 are also very important in the choice of cables for given conditions and emphasis is placed on these requirements.

Outcome 4 brings together all the strategies and concepts developed in the previous outcomes and allows you to carry out a simple design exercise. You will be given a limited specification for part of an installation and asked to select the cable sizes, types of cable, switchgear, earthing arrangements and installation methods and to produce documentation to support your work. This design exercise will be assessed and will give you the confidence to undertake installation design under practical working conditions.