T Level Technical Qualification in Construction: Building Services Engineering (BSE) (Level 3) (delivered by City & Guilds) (8710-31)

May 2020 Version 1.5

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## Qualification at a glance

<table>
<thead>
<tr>
<th>T Level route</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>T Level pathway</td>
<td>Building Services Engineering (BSE)</td>
</tr>
<tr>
<td>City &amp; Guilds number</td>
<td>8710-31</td>
</tr>
<tr>
<td>Age group approved</td>
<td>16+</td>
</tr>
<tr>
<td>Entry requirements</td>
<td>Formal entry requirements are not set by City &amp; Guilds. However, we would expect that Learners have the appropriate attainment at Level 2 before commencing their studies.</td>
</tr>
</tbody>
</table>
| Assessment | Core - knowledge tests are externally assessed  
Core – employer-set project is externally assessed  
Occupational specialisms are externally moderated |
| First registration | September 2021 |
| Total GLH | TBC |
| Total TQT | TBC |

### Title and level

<table>
<thead>
<tr>
<th>Title and level</th>
<th>City &amp; Guilds number</th>
</tr>
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<tbody>
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<td>8710-31</td>
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<td>Content of components</td>
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<td>350 Building services engineering core</td>
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<td>What is the component about?</td>
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<td>Specialism content</td>
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<td>Electrical and electronic equipment engineering</td>
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<td>Electrotechnical engineering</td>
<td>125</td>
</tr>
<tr>
<td>Gas engineering</td>
<td>151</td>
</tr>
<tr>
<td>Heating engineering</td>
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</tr>
<tr>
<td>Plumbing engineering</td>
<td>204</td>
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<tr>
<td>Protection systems engineering</td>
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Underpinning knowledge outcomes: 39
BSE Core content: 40
Guidance for delivery: 78

351 Air conditioning engineering
What is this specialism about?: 80
Specialism content: 81
Specific knowledge criteria for performance outcomes: 85
Links to Core Skills: 100
Guidance for delivery: 100

352 Electrical and electronic equipment engineering
What is this specialism about?: 102
Specialism content: 104
Specific knowledge criteria for performance outcomes: 107
Links to Core Skills: 123
Guidance for delivery: 123

353 Electrotechnical engineering
What is this specialism about?: 125
Specialism content: 127
Specific knowledge criteria for performance outcomes: 131
Links to Core Skills: 148
Guidance for delivery: 149

354 Gas engineering
What is this specialism about?: 151
Specialism content: 152
Specific knowledge criteria for performance outcomes: 159
Links to Core Skills: 176
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355 Heating engineering
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Specialism content: 179
Specific knowledge criteria for performance outcomes: 184
Links to Core Skills: 201
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356 Plumbing engineering
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Specialism content: 205
Specific knowledge criteria for performance outcomes: 211
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### 359 Ventilation

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<td>Specialism content</td>
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<td>Specific knowledge criteria for performance outcomes</td>
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1 Introduction

What is this qualification about?

The following purpose statement relates to the T Level Technical Qualification in Construction: Building Services Engineering (BSE) (Level 3) (delivered by City & Guilds)

<table>
<thead>
<tr>
<th>Area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OVERVIEW</strong></td>
<td></td>
</tr>
<tr>
<td>What is a T Level?</td>
<td>T Levels are new courses which will follow GCSEs and will be equivalent to 3 A Levels. These 2-year courses have been developed in collaboration with employers and businesses so that the content meets the needs of industry and prepares learners for work.</td>
</tr>
<tr>
<td></td>
<td>A T level is one of three post 16 options for young people which are:</td>
</tr>
<tr>
<td></td>
<td>• A Levels</td>
</tr>
<tr>
<td></td>
<td>• Apprenticeships</td>
</tr>
<tr>
<td></td>
<td>• T Level</td>
</tr>
<tr>
<td>How does the Technical Qualification work within the T Level?</td>
<td>This Technical Qualification specification contains all the required information you need to deliver the qualification in the T Level in Construction: Building Services Engineering.</td>
</tr>
<tr>
<td></td>
<td>The Technical Qualification forms a significant part of the T Level Technical Qualification in Construction: Building Services Engineering (BSE). City &amp; Guilds are responsible for the development and ongoing operational delivery of this Technical Qualification. All other parts of the T Level as listed below will need to be achieved by a Learner for the Department for Education to award the successful completion of this T Level. It is important to note that City &amp; Guilds do not have responsibility of delivery for the other parts of the T Level but will continue to support centres where they can on all aspects of T Level delivery.</td>
</tr>
<tr>
<td></td>
<td>Additional mandatory parts of the T Level that need to be achieved:</td>
</tr>
<tr>
<td></td>
<td>• A 315-hour minimum industry placement</td>
</tr>
<tr>
<td></td>
<td>• Level 2 Functional skills or GCSE English and Maths at grade 4 or above</td>
</tr>
</tbody>
</table>

1 T Level is a registered trade mark of the Institute for Apprenticeships and Technical Education
| **Who is this qualification for?** | This qualification is for you if you are a 16-19-year-old learner who wishes to work within the Building Services Engineering Industry. It has been designed to deliver a high level of knowledge about the BSE industry as well as the occupational skills required to enter the industry (known as ‘threshold competence’). A learner who completes this qualification is well placed to develop to full occupational competence with the correct support and training. |
| **What does this qualification cover?** | The qualification will help you gain an understanding of the BSE industry and the sector and you will cover topics such as: Health and Safety, construction science principles, sustainability in the construction industry and building services engineering systems. A learner will have the choice of studying two occupational specialisms from the list below:  
• Air conditioning engineering  
• Electrical and electronic equipment engineering  
• Electrotechnical engineering  
• Gas engineering  
• Heating engineering  
• Plumbing engineering  
• Protection systems engineering  
• Refrigeration engineering  
• Ventilation engineering  
Centres and providers work with local employers who will contribute to the knowledge and delivery of training. Employers will provide demonstrations and talks on the industry and where possible work placements will also be provided by the employers. |
| **WHAT COULD THIS QUALIFICATION LEAD TO?** | This technical qualification focuses on the development of knowledge and skills needed for working in the Building Services Engineering industry, which will prepare you to enter the industry through employment or as an Apprentice. Furthermore, the completion of this qualification gives the learner the opportunity to progress onto higher education courses and training. |
| **Will the qualification lead to employment, and if so, in which job role and at what level?** | This qualification will suit someone who is not yet employed or looking to enter the industry post mainstream education. The structure of the qualification is designed to give learners the breadth of knowledge and understanding across the BSE industry but also equips them with necessary occupational and core skills to enter the industry. This qualification is designed to support fair |
access and allows learners to manage and improve their own performance.

### WHO SUPPORTS THIS QUALIFICATION?

| Employer route panels | The content of this qualification is outlined by a representative panel of employers from across the industry sector. It therefore prescribes the minimum knowledge and skills required to enter the industry. The content in this specification is approved by the Institute for Apprenticeships and Technical Education (IFATE). |
Employer support page
Glossary of terms
The below provides a summary of the key information provided to centres to aide and support in the delivery of this Technical Qualification

Guided learning hour (GLH) value
This value indicates the amount of Guided Learning Hours a unit will require for delivery to a learner on average. This includes contact with tutors, trainers or facilitators as part of the learning process, and includes formal learning including classes, training sessions, coaching, seminars and tutorials. This value also includes the time taken to prepare for, and complete, the assessment for the unit. Guided learning hours are rounded up to the nearest five hours.

Total qualification time (TQT) value
Total Qualification Time (TQT) is the total amount of time, in hours, expected to be spent by a Learner to achieve a qualification. It includes both guided learning hours (which are listed separately) and hours spent in preparation, study and assessment.

Criteria
This section of the specification outlines the subject or topic that needs to be delivered and assessed. Criteria is often supported by ‘range’ which provides the detail of the information required to be delivered as part of that topic. For example, with BSE systems as the topic, the range would list the systems that would need to be covered in delivery and assessment.

What do learners need to learn?
The primary purpose of the ‘What do learners need to learn’ sections is to support the delivery of the content in the criteria. These sections provide context in relation to the depth and breadth that something needs to be taught.

Skills
The skills section provides a mapping reference to the core, maths, English and digital skills that are embedded within the Technical Qualification content.

Example

<table>
<thead>
<tr>
<th>3.3 Role of different disciplines involved in design.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Range:</strong></td>
</tr>
<tr>
<td>Disciplines - Contractors and all operatives, architects and all professional occupations, planners and building inspectors, manufacturers</td>
</tr>
</tbody>
</table>

What do learners need to learn?
A basic knowledge of key job roles within construction design including the responsibilities and reporting lines/lines of escalation within roles. The key activities aligned to the disciplines with an appreciation of potential career progression routes.
Technical Qualification Structure

The Technical Qualification is made up of two components. Both of which need to be successfully achieved in order to attain the Technical Qualification as well as the full T Level in Construction: Building Services Engineering.

The Core Component:
The core component is designed to offer the sufficient breadth of knowledge and skills a learner will need and be able to apply in a variety of contexts related to the industry and those occupational specialisms linked to this T Level.

The core content is the building blocks of knowledge and skills that gives a learner a broad understanding of the industry and job roles. While at the same time developing the core skills they will need to apply when working within the industry.

Occupational Specialisms:
Occupational specialisms develop the knowledge, skills and behaviours necessary to achieve threshold competence in an occupation. Threshold competence is defined as being when a learner’s attainment against the knowledge, skills and behaviours is of a standard to enter the occupation and industry. While demonstrating the ability to achieve occupational competence over time with the correct support and training.

Insert visual
To achieve the **T Level Technical Qualification in Construction: Building Services Engineering (BSE) (Level 3) (delivered by City & Guilds)** learners must achieve the two components of the Technical qualification. These are known as the core component and the occupational specialism:

- Building services engineering core component (350)
- plus **two** occupational specialism components that must be (351 & 358) or (355 & 359) or (356 & 355) or **one** occupational specialism component that must be (353) or (354) or (357) or (352)

### T Level Technical Qualification in Construction: Building Services Engineering (BSE) (Level 3)

<table>
<thead>
<tr>
<th>City &amp; Guilds component number</th>
<th>Component title</th>
<th>Component level</th>
<th>GLH (provisional)</th>
<th>TQT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mandatory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>350</td>
<td>Building services engineering core content</td>
<td>Level 3</td>
<td>520</td>
<td>TBC</td>
</tr>
<tr>
<td><strong>Optional (two must be chosen)</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>351</td>
<td>Air conditioning engineering</td>
<td>Level 3</td>
<td>TBC</td>
<td>TBC</td>
</tr>
<tr>
<td>352</td>
<td>Electrical and electronic equipment engineering</td>
<td>Level 3</td>
<td>TBC</td>
<td>TBC</td>
</tr>
<tr>
<td>353</td>
<td>Electrotechnical engineering</td>
<td>Level 3</td>
<td>TBC</td>
<td>TBC</td>
</tr>
<tr>
<td>354</td>
<td>Gas engineering</td>
<td>Level 3</td>
<td>TBC</td>
<td>TBC</td>
</tr>
<tr>
<td>355</td>
<td>Heating engineering</td>
<td>Level 3</td>
<td>TBC</td>
<td>TBC</td>
</tr>
<tr>
<td>356</td>
<td>Plumbing engineering</td>
<td>Level 3</td>
<td>TBC</td>
<td>TBC</td>
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<tr>
<td>357</td>
<td>Protection systems engineering</td>
<td>Level 3</td>
<td>TBC</td>
<td>TBC</td>
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<td>358</td>
<td>Refrigeration engineering</td>
<td>Level 3</td>
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<td>359</td>
<td>Ventilation</td>
<td>Level 3</td>
<td>TBC</td>
<td>TBC</td>
</tr>
</tbody>
</table>

### Title and level

<table>
<thead>
<tr>
<th>T Level Technical Qualification in Construction: Building Services Engineering (BSE) (Level 3) (delivered by City &amp; Guilds)</th>
<th>GLH</th>
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<tbody>
<tr>
<td>TBC</td>
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</tbody>
</table>
2 Centre requirements

Approval

New centres will need to gain centre approval. Existing centres who wish to offer this qualification must go through City & Guilds’ full Qualification Approval Process. There is no fast track approval for this qualification. Please refer to the City & Guilds website for further information on the approval process: www.cityandguilds.com

Provider and Technical qualification approval criteria

As part of the approval application, the Provider will be required to demonstrate they meet the TQ approval criteria. The application form will include a self-assessment, where the Provider will confirm the appropriate policies, procedures or processes are in place and provide evidence on how these are met.

<table>
<thead>
<tr>
<th>Management systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective systems in place to ensure communication between all levels of staff within the organisation and to ensure information is shared.</td>
</tr>
<tr>
<td>Effective systems for communication across placements and staff who work remotely or externally to central location.</td>
</tr>
<tr>
<td>Provider Senior Management will ensure sufficient time and resource is allocated to ensure effective delivery of the TQ and will review this annually.</td>
</tr>
<tr>
<td>Effective systems in place to monitor and review the effectiveness of TQ delivery and assessment.</td>
</tr>
<tr>
<td>Robust and effective process in place to monitor delivery and/or assessment risks and to implement changes or allocate resource appropriately.</td>
</tr>
<tr>
<td>Provider has appropriate documented policies and procedures relating to; • Learner recruitment and induction (including registration) • Ongoing Learner support • Ongoing staff support • Safeguarding • Equality, diversity and inclusivity • Reasonable adjustments • Appeals • Learner/staff malpractice, maladministration and plagiarism • Complaints • Conflict of Interest • GDPR • Risk assessments • Health &amp; Safety (including public liability) • Contingency planning (to include in cases of withdrawal of Provider approval).</td>
</tr>
<tr>
<td>Process in place for annual review of above policies and procedures.</td>
</tr>
<tr>
<td>Process to notify Awarding Organisation of any changes pertaining to the delivery and/or assessment of the TQ (e.g. staff changes).</td>
</tr>
<tr>
<td><strong>Effective system in place to store accurate and up to date staff data (including CVs, qualification certificates, CPD evidence etc.).</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Process in place to notify Awarding Organisation and other relevant parties where changes to the delivery and/or assessment of the TQ may affect the Providers ability to meet our approval criteria.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Effective system in place to store accurate and up to date Learner data (including Learner details, assessment and internal verification records, records of standardisation etc.).</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>All Learner data is stored securely in line with GDPR and data protection legislation. Provider will ensure all assessment records are retained for a minimum period of three years post certification.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Industry placement</strong></th>
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</thead>
</table>
| Provider has appropriate documented policies and procedures relating to:  
  - Risk assessment and/or health and safety assessment of placement  
  - Quality assurance of placements  
  - Ongoing monitoring of placement. |

<table>
<thead>
<tr>
<th><strong>Resources</strong></th>
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</table>
| Provider has access to the appropriate resources to meet the specification of the TQ and its delivery and assessment.  
There are sufficient staff to meet the demand of the TQ.  
Staff have the relevant competencies, occupational competence and knowledge required for the delivery and/or assessment of the TQ.  
There are effective systems in place to ensure staff are adequately supported in their role.  
Effective systems are in place to ensure Continuous Professional Development (CPD) of all staff involved in the delivery of the TQ.  
Staff have adequate time and access to complete CPD.  
Resources for assessment in the workplace or Realistic Working Environment (RWE) as specified by the standards setting body/specification are available and are robust.  
Any third-party agreements are recorded, impact assessed and made available for review. (It may be necessary for the TQ Approval and Support Consultant to check suitability of premises and resources for third-party agreements). |

<table>
<thead>
<tr>
<th><strong>Delivery</strong></th>
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| There is a detailed programme of delivery plan in place which is realistic and meets the needs of the TQ specification. Evidence of this may include a detailed induction process or plan for Learners or cohorts, a curriculum plan or scheme of work.  
There is an initial diagnostics process in place for all Learners to ensure they are suitably supported.  
There is a process in place to ensure Learners’ individual needs are assessed, matched against the requirements for the TQ and an individual assessment plan implemented (including initial diagnostics).  
There are regular opportunities to review Learner progress and support.  
Learners receive a handbook which contains accurate information relating to the delivery of the TQ. |
Learners are advised of any technical needs for the TQ and the support that will be delivered by the Provider.

**Assessment and standardisation plan**

- Plan in place to ensure all Internal Assessors and key staff are trained in line with the marking, standardisation and moderation guidance provided by City & Guilds.
- Provider has a detailed and robust plan of how they intend to ensure that Internal Assessors and quality assurance staff will be adequately trained to ensure reliable and consistent marking.
- Provider has a detailed and robust plan how they intend to ensure that there is an effective internal quality assurance process to actively monitor marking.
- Understanding of how additional activities (webinars, training workshops etc.) provided by City & Guilds will support reliable marking and standardisation.
- An effective standardisation plan is in place to ensure accurate, consistent and standardised marking across all Internal Assessors.
- Provider can outline how it will identify and mitigate any risk where an Internal Assessor is deemed not to be providing reliable results.

**Secure live assessment and administration**

- Providers will comply with the requirements set out by City & Guilds for the delivery and assessments of the TQ.
- There are effective procedures in place to identify assessment that may not be the Learner’s own work (plagiarism).
- There are effective procedures in place to confirm Learners’ identification and record Learners’ attendance.
- There is a clearly identified Exam policy and procedure that meets with City & Guilds requirements for the TQ, as well as JCQ ICE requirements.
- The Provider has in place a detailed Invigilation policy and can demonstrate that Invigilators are suitable trained.
- Assessment locations are known to City & Guilds and meet with City & Guilds and JCQ ICE requirements.
- The Provider ensures the safe storage, distribution and collection of all assessment and/or Exam material in line with JCQ ICE requirements.
- Systems are in place to ensure only authorised personnel have access to assessment or Exam material and the platforms used to facilitate online Exams.
Resource requirements
Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualification before designing a course programme.

Centre staffing
Staff delivering these qualifications must be able to demonstrate that they meet the following requirements:

- Be occupationally competent at or above the level they are delivering
- Be able to deliver across the breadth and depth of the content of the qualification being taught
- Have recent relevant teaching and assessment experience in the specific area they will be teaching, or be working towards this
- Demonstrate continuing CPD
- Experience or training in the following will support the delivery of this Technical Qualification:
  - Delivering project-based qualifications
  - Preparation for exam-based assessments

BSE Core
Staff who are familiar with L3 Construction/BSE qualifications will be able to teach the core subjects.

Occupational specialisms specific requirements

Electrotechnical engineering
Hold an NVQ level 3 in Electrical Installations (City and Guilds 2330+2350(6)/2357/5357), have an AM2 qualification or have current JIB or ECS Gold card registration.

Gas engineering
TBC

Protection systems
Hold an NVQ level 3 in Electrical Installations (City and Guilds 2330+2350(6)/2357/5357), have an AM2 qualification or have current JIB or ECS Gold card registration.

Electrical and electronic equipment
Hold an NVQ level 3 in Electrical Installations (City and Guilds 2330+2350(6)/2357/5357), have an AM2 qualification or have current JIB or ECS Gold card registration.

Plumbing and Heating
TBC

Heating and ventilation
TBC
Air condition and refrigeration engineering

TBC

Staff assessing these qualifications must meet the above requirements as well as hold or be working towards a relevant recognised assessor qualification such as a Level 3 Certificate in Assessing Vocational Achievement and continue to practice to that standard. Assessors who hold earlier qualifications (D32 or D33 or TQFE/TQSE) should have CPD evidence to the most current standards. Assessors must also hold a relevant trade qualification and/or having registration with a relevant trade organisation as ‘Approved tradesperson’ status or ‘Eng-Tech’ status.

Physical resources

Centres must be able to demonstrate that they have access to the equipment and technical resources required to deliver this qualification and its assessment.

Specific resources per specialisms to be added when finalised
Internal quality assurance

Internal quality assurance is key to ensuring accuracy and consistency of tutors and markers. Internal Quality Assurers (IQAs) monitor the work of all tutors involved with a qualification to ensure they are applying standards consistently throughout assessment activities. IQAs must have, and maintain, an appropriate level of technical competence and be qualified to make both marking and quality assurance decisions through a teaching qualification or recent, relevant experience.

Learner entry requirements

Centres must ensure that all learners have the opportunity to gain the qualification through appropriate study and training, and that any prerequisites stated in the What is this qualification about? section are met when registering on this qualification.

Formal entry requirements are not set by City & Guilds but we would expect learners to have qualifications at Level 2 or equivalent. This may include:

- GCSEs at grade 4 or above including English and maths
- Level 2 vocational qualification or equivalent in a related subject. For example Construction and the Built Environment
3 Delivering T Level Technical Qualifications

Initial assessment and induction

An initial assessment of each learner should be made before the start of their programme to identify:
- if the learner has any specific training needs,
- support and guidance they may need when working towards their qualification,
- the appropriate type and level of qualification.

We recommend that centres provide an introduction so that learners fully understand the requirements of the qualification, their responsibilities as a learner, and the responsibilities of the centre. This information can be recorded on a learning contract.

Programme delivery

The Technical Qualification should be delivered through approaches that meet the needs of your learners. We would recommend using a variety of delivery methods including both classrooms and real work environments. Learners may benefit from both direct instruction in more formal learning environments and taking part in investigative projects, e-learning and their own study and learning through indirect approaches to delivery.
4. Competency frameworks

The Technical Qualification has been developed to include competency frameworks for T Levels which demonstrates an array of competencies across maths, English and digital skills as well as four key core skills that have been mapped into the core content. This can be seen in the skills section for each criterion.

Core skills
In the design, delivery and assessment of the Technical Qualification the below core skills are fundamental in the development of the required knowledge, skills and behaviours that learners will need to use when they progress on from completing their T Level. These core skills have been mapped in the design of the qualification content and developed in consultation with industry and providers. The mapping identifies the opportunities where these core skills can be developed and embedded into teaching and learning. It is not expected that all criteria will develop core skills but where these skills exist in the core content it has been referenced to support centres.

- **Core skill A (CSA) Applying a logical approach to solving problems, identifying issues and proposing solutions e.g. through setting criteria for successful implementation of a system, using cost / benefit analysis of the introduction of new procedures or equipment**
  - The advantage and disadvantages of system selection and their application in various settings
  - The various components that make up both pipework and ducting systems and how they affect BSE systems
  - Produce risk assessments, method statements and safe system of works
  - The key stages of the design process
  - The different types of sustainable solutions listed in the range and how they are used to inform the building process
  - The different Insulation materials, controls and monitoring systems (BMS) used to improve energy efficiency in buildings
  - The use of both manufacturer instructions and technical guidance to solve problems
  - Complying with data storage requirements in relation to security and protection
  - The use of technology connected to the internet of things and its role in the construction industry to assist in just in time and asset management.
  - The use of digital engineering techniques in the construction industry and where to apply them
  - Utilising benchmarking, KPI's and target setting when measuring business success.
  - Ensuring the key requirements of Building Regulations and approved documents are implemented within projects
  - Applying a logical approach to maintenance activities
• **Core skill B (CSB)** Primary research e.g. obtaining measurements related to a design and/or customer requirement
  
  - Collect information on Building Services Engineering systems
  - Research the various components that make up Building Services Engineering systems
  - Researching health and safety requirements to produce risk assessments, method statements and safe systems of work
  - Researching construction materials to ascertain their properties and suitability
  - Researching construction design job roles
  - The structure of the construction industry, including business types
  - The role and importance of CPD
  - Sustainable construction solutions
  - Researching the techniques aimed at maximising value and minimising waste within industry
  - Research the requirements of current UK Building Regulations to ensure compliance
  - The procedures and processes for penetrating building structure as detailed in the building regulations
  - Standards regulation and guidance used to maintain good practice within the construction industry
  - Researching corporate social responsibility principles for a range of organisations
  - Use current UK and international standards (BSEN)

• **Core skill C (CSC)** Communication e.g. providing information and advice to customers and/or wider stakeholders on the potential risks of a change to an industrial system, or making a presentation to a stakeholder on the implications of change
  
  - Present installation plans to key stakeholders or the client
  - Present risk assessments, method statements and safe systems of work to enable safe working
  - Communicate with the end user when safely isolating services/systems
  - Communication when unsafe situations occur in the workplace following the current HSE reporting requirements
  - Communicate the potential implications of poor design to the different parties affected in the construction chain
  - Explaining the benefits to contractors, the client/customer, to profitability and project success detailing the implications of not having accurate measurements
  - Communicate Information and data sources for construction projects
  - Communicate using BIM and workflow software packages
  - Promote good customer service providing information and advice to customers
  - Implement change requests from various parties, including clients
  - Communicate using technology connected to the internet of things and their role in the construction industry to assist in just in time and asset management.
  - Setting clear project goals and objectives, defining roles, setting realistic milestones and constraints on cost and time.
  - Communicate BSE system maintenance requirements with end users
• **Core skill D (CSD)** Working collaboratively with other team members and stakeholders e.g. to develop content to bid for a construction project

- Take part in group discussions and presentations in collating information in response to a specification or client brief
- Follow the correct procedures for reporting an incident or near miss in the workplace
- Reporting lines/lines of escalation within construction roles
- Integration of all partners of the supply chain
- Building information modelling and the effect they have on real time project delivery in a collaborative way
- Work collaboratively with the different types of stakeholders e.g. client, team and end user
- Collaborative approach to project delivery and reporting, and how this is applied in practice with the use of BIM and workflow software packages
- Working with a range of individuals applying equality and diversity legislation
- The use of conflict management techniques
- Behaving in an ethical way towards other team members and stakeholders
- Fundamental business values and commitment to customers and collaborative working with others
- Work collaboratively to ensure quality management systems are completed
- Ensuring team members and stakeholders know the key requirements of Building Regulations and approved documents
**Maths, English and digital skills**

Maths, English and digital skills have been mapped across the core content and each of the occupational specialisms. The lists below identify the core competencies which can be found in the skills sections of each performance criteria.

**General English Competencies**

The General English Competencies outline a framework of six General Digital Competences, with no prioritisation or interpretation of order intended:

EC1. Convey technical Information to different audiences  
EC2. Present information and ideas  
EC3. Create texts for different purposes and audiences  
EC4. Summarise information/ideas  
EC5. Synthesise information  
EC6. Take part in/lead discussions

**General Mathematical Competencies**

The General Mathematical Competencies outline a framework of ten General Mathematical Competences, with no prioritisation or interpretation of order intended:

MC1. Measuring with precision  
MC2. Estimating, calculating and error spotting  
MC3. Working with proportion  
MC4. Using rules and formulae  
MC5. Processing data  
MC6. Understanding data and risk  
MC7. Interpreting and representing with mathematical diagrams  
MC8. Communicating using mathematics  
MC9. Costing a project  
MC10. Optimising work processes

**General Digital Competencies**

The following outlines a framework of six General Digital Competences, with no prioritisation or interpretation of order intended:

DC1. Use digital technology and media effectively  
DC2. Design, create and edit documents and digital media  
DC3. Communicate and collaborate  
DC4. Process and analyse numerical data  
DC5. Be safe and responsible online  
DC6. Controlling digital functions
5 Assessment

Assessment methods

**Learners must complete:**

**two** externally set exams covering knowledge from the building services engineering core content (component 350)

The exams provide sufficient sampling of the content, and consisting of a mixture of short answer questions (SAQ), some of which will be structured, and extended response. The balance of questions in assessing across Assessment Objectives (AOs) 1, 2 and 3 will allow for the appropriate differentiation of Learners to support in the reliable setting of boundaries.

**one** employer-set project covering knowledge and skills from the building services engineering core (component 350)

The employer-set project will be made up of well defined, real, industry style brief. The brief will be complex and non-routine and require the use of relevant maths, English and digital skills. The brief will provide a valid context for the Level 3 candidate to demonstrate their knowledge and understanding of the Core content and their Core skills to solve occupationally relevant situations and/or problems.

**And**

**two** occupational specialisms from (351 & 358) or (355 & 359) or (356 & 355)

**Or**

**one** occupational specialism from (353) or (354) or (357) or (352)

These assessments will feature a considerable practical element and are composed of a series of holistic practical tasks relating to the specialism at hand. They will take place over a period of time, scheduled at the Providers’ preference within an approximate three-month assessment window. By nature of the considerable practical elements, the tasks will generate significant ephemeral evidence and be heavily reliant on Internal Assessor observation notes and records for validation.

**Grading and marking**

- The building services engineering core (component 350) is graded overall A* - E plus ungraded (U)
- The occupational specialisms (components 351 – 359) are graded overall Distinction, Merit, Pass and Ungraded. Each occupational specialism achieved will receive a grade*.

*Although it is mandatory for some specialisms to be taken within a combination this is only for delivery purposes. Each occupational specialism with have its own practical assignment that will attest for threshold competence. As an example, if a learner decided to take Plumbing and heating as a combination they would need to complete an assignment for both specialisms. If a learner decided to take Electrotechnical engineering only one practical assignment would need to be taken.*

---

T Level Technical Qualification in Construction: Building Services Engineering (BSE) (Level 3) (delivered by City & Guilds)
**Technical Qualification Assessment structure.**

### Core Component – Learners must complete all assessment components

<table>
<thead>
<tr>
<th>Assessment component</th>
<th>Method</th>
<th>Duration</th>
<th>Marks</th>
<th>Weighting</th>
<th>Marking</th>
<th>Grading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam paper 1</td>
<td>Externally set exam</td>
<td>2.5 hours</td>
<td>110</td>
<td>35%</td>
<td>Externally marked</td>
<td>This component will be awarded on the grade scale A* - E</td>
</tr>
<tr>
<td>Exam paper 2</td>
<td>Externally set exam</td>
<td>2.5 hours</td>
<td>110</td>
<td>35%</td>
<td>Externally marked</td>
<td></td>
</tr>
<tr>
<td>Employer set project</td>
<td>Externally set project</td>
<td>18 hours</td>
<td>TBC</td>
<td>30%</td>
<td>Externally marked</td>
<td></td>
</tr>
</tbody>
</table>

### Occupational Specialism Component - Learners must complete two assessment components

<table>
<thead>
<tr>
<th>Assessment component</th>
<th>Method</th>
<th>Duration</th>
<th>Marks</th>
<th>Weighting</th>
<th>Marking</th>
<th>Grading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrotechnical engineering</td>
<td>Externally set assignment</td>
<td>TBC</td>
<td>TBC</td>
<td>100%</td>
<td>Externally moderated</td>
<td></td>
</tr>
<tr>
<td>Plumbing</td>
<td>Externally set assignment</td>
<td>14 hours</td>
<td>90</td>
<td>100%</td>
<td>Externally moderated</td>
<td></td>
</tr>
<tr>
<td>Air conditioning engineering</td>
<td>Externally set assignment</td>
<td>TBC</td>
<td>TBC</td>
<td>100%</td>
<td>Externally moderated</td>
<td></td>
</tr>
<tr>
<td>Electrical and electronic equipment</td>
<td>Externally set assignment</td>
<td>TBC</td>
<td>TBC</td>
<td>100%</td>
<td>Externally moderated</td>
<td></td>
</tr>
<tr>
<td>Gas engineering</td>
<td>Externally set assignment</td>
<td>14 hours</td>
<td>90</td>
<td>100%</td>
<td>Externally moderated</td>
<td></td>
</tr>
</tbody>
</table>

All occupational specialism components will be awarded on the grade scale P, M, D.
<table>
<thead>
<tr>
<th>Course</th>
<th>Method</th>
<th>TBC</th>
<th>TBC</th>
<th>100%</th>
<th>Moderation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating engineering</td>
<td>Externally set</td>
<td>TBC</td>
<td>TBC</td>
<td>100%</td>
<td>Externally moderated</td>
</tr>
<tr>
<td>Protection systems engineering</td>
<td>Externally set assignment</td>
<td>TBC</td>
<td>TBC</td>
<td>100%</td>
<td>Externally moderated</td>
</tr>
<tr>
<td>Refrigeration engineering</td>
<td>Externally set assignment</td>
<td>TBC</td>
<td>TBC</td>
<td>100%</td>
<td>Externally moderated</td>
</tr>
<tr>
<td>Ventilation</td>
<td>Externally set</td>
<td>TBC</td>
<td>TBC</td>
<td>100%</td>
<td>Externally moderated</td>
</tr>
</tbody>
</table>
Core component assessment

The assessments for this component consist of two core exams and an employer-set project which are set against a set of assessment objectives (AOs) which are used to promote consistency among qualifications of a similar purpose. They are designed to allow judgement of the candidate to be made across a number of different categories of performance.

Each assessment for this component has been allocated a set number of marks against these AOs based on weightings recommended by stakeholders of the qualification. This mark allocation remains the same for all versions of the assessments, ensuring consistency across assessment versions and over time.

Assessment objective weightings for the assessment components related to the core content are detailed below.
# Core exam

<table>
<thead>
<tr>
<th>Assessment objective</th>
<th>Description</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AO1 a</strong> Demonstrate knowledge</td>
<td>All AOs require the ability to recall knowledge. AO1a) refers to instances where the learner is simply required to demonstrate basic recall. In the test, this helps to give confidence in sufficiency of coverage of the content, and recognises that not all knowledge requires further understanding eg terminology, number facts etc.</td>
<td>10%</td>
</tr>
<tr>
<td><strong>AO1 b</strong> Demonstrate understanding</td>
<td>The ability to explain principles and concepts beyond recall of definitions in order to be able to transfer these principles and concepts between contexts. Learners have built connections between related pieces of knowledge. AO1b) focuses on the ability of the learners to show understanding by summarising or explaining concepts in their own words, exemplifying or comparing and making inferences in general terms that show eg cause and effect.</td>
<td>25%</td>
</tr>
<tr>
<td><strong>AO2</strong> Apply knowledge and understanding to different situations and context</td>
<td>Using and applying knowledge and understanding, of processes, procedures, generalisations principles and theories to specified, concrete situations. AO2 is about being able to take the understanding of generalities (AO1b) and apply them to specific novel situations. It is more granular than the more extended synthesis/creation that may respond to an analysis (AO3a) of a more holistic complex situation/brief.</td>
<td>45%</td>
</tr>
<tr>
<td><strong>AO3</strong> Analyse and evaluate information and issues</td>
<td>Learners will be provided with information e.g. in the form of a detailed scenario requiring the Learners to analyse the interrelated issues arising and evaluate, for example, the strengths and weaknesses or advantages and disadvantages of approaches they may take to achieve a good outcome. Marks will be given for the quality of analysis and evaluation and the range of considerations considered.</td>
<td>20%</td>
</tr>
<tr>
<td>Assessment objective</td>
<td>Typical evidence</td>
<td>Approximate weighting</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td><strong>AO1</strong> Planning skills and strategies</td>
<td>Clearly structured response to brief, cohesive response with ordered sections, logical approach to referencing, research and sources, response completed to deadline and meeting required parameters, sources used effectively and integrated into response (not just an afterthought), effective use of time allocation available for presentations.</td>
<td>10%</td>
</tr>
<tr>
<td><strong>AO2</strong> Apply knowledge and skills to the context of the project</td>
<td>Relevant core knowledge applied to respond to brief, references relevant legislation, building controls materials, concepts, waste disposal and site access considerations.</td>
<td>50%</td>
</tr>
<tr>
<td><strong>AO3</strong> Analyse contexts to make informed decisions</td>
<td>Analysis of key issues, evidence of risk rating and prioritisation of key issues relating to brief, drawing together considerations and considering impacts of elements on each other (not just in isolation), consideration and analysis of the reasons for doing things in a particular way</td>
<td>20%</td>
</tr>
<tr>
<td><strong>AO4</strong> Use Maths, English and Digital skills</td>
<td>Use of correct terminology, abbreviations, units of measurement in context, consideration of audience of brief response (technical vs non-technical wording), use of calculations / graphs etc appropriately, consideration of the use of ICT and digital methods both in brief response and in presentation</td>
<td>10%</td>
</tr>
<tr>
<td><strong>AO5</strong> Carry out tasks and evaluate for fitness for purpose</td>
<td>Considered analysis and evaluation of project outcome, what went well and what could be improved, response conclusion or evaluation section, identification of solutions in response to brief problem with evidence of evaluation of other options and reasons for rejection of other options where not appropriate</td>
<td>10%</td>
</tr>
</tbody>
</table>
Summary of core assessment methods and conditions

<table>
<thead>
<tr>
<th>Component</th>
<th>Assessment method</th>
<th>Description and conditions</th>
</tr>
</thead>
</table>
| Core exam  | Externally marked tests      | These tests are **externally set and externally marked**, and will be sat through paper passed question papers provided by City & Guilds. These tests are designed to assess candidate’s depth and breadth of understanding across the core component in the qualification at the end of the period of learning, and will be sat under invigilated examination conditions. See JCQ requirements for details: [http://www.jcq.org.uk/exams-office/ice---instructions-for-conducting-examinations](http://www.jcq.org.uk/exams-office/ice---instructions-for-conducting-examinations) For the first sitting the Core exams and Employer-set project must be taken in the same assessment window. Following this they can re sit in any assessment window as long as the below condition is met:  
  - Candidates who fail either one or both exams in the core exam will need to re sit both exams and must do in the same assessment window. |
<table>
<thead>
<tr>
<th>Component</th>
<th>Assessment method</th>
<th>Description and conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employer-set project</td>
<td>Externally marked project</td>
<td>This project is <strong>externally set and externally marked</strong>, and is designed to require the candidate to identify and use effectively in an integrated way an appropriate selection of skills, techniques, concepts, theories, and knowledge from across the whole of the BSE core. Projects will be released to centre staff towards the end of the learners' programme, usually the week before Easter each year. Centres will be required to maintain the security of all live assessment materials until assessment windows are open. Projects will therefore be password protected and released to centres through a secure method. Guidance on equipment, resources and duration will be released as appropriate to ensure centres can plan for delivery of the project in advance. The marking grid for the project will be available to centres from the start of the learning programme. Candidates who fail the Employer-set project on first the submission can resit in any assessment window. If a candidate fails both the core exams and the Employer-set project after the first sitting they do not need to be retaken in the same assessment window.</td>
</tr>
</tbody>
</table>
Occupational specialism component assessment

Occupational specialism assessments will be set and assessed at task level. Each task will have a number of sub tasks that will produce types of assessment themes (type of performance/ evidence). Assessment themes will be broad enough to ensure all performance criteria across the specialism are assessed ensuring the assessment is as valid & reliable as possible. The assessment themes will be the same in every version of the assignment ensuring comparability between performances in every version of the assessment. Sub tasks will allow flexibility at the setting stage of the assignment to ensure predictability is avoided.

The assessment for this component has been allocated a set number of marks against tasks based on recommendations by a panel of technical experts. This mark allocation remains the same for all versions of the assessments, ensuring consistency across assessment versions and over time.

<table>
<thead>
<tr>
<th>Assessment method</th>
<th>Grade scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical assignment</td>
<td>U/P/M/D</td>
</tr>
<tr>
<td>Component</td>
<td>Assessment method</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------</td>
</tr>
<tr>
<td>Occupational specialism assignment</td>
<td>Externally set, externally moderated</td>
</tr>
</tbody>
</table>

Assignments will be released to centre staff towards the end of the learners’ programme, usually the week before Easter each year.

Centres will be required to maintain the security of all live assessment materials until assessment windows are open. Assignments will therefore be password protected and released to centres through a secure method.

Guidance on equipment, resources and duration will be released as appropriate to ensure centres can plan for delivery of practical assignments in advance. The marking grid for the assignment will be available to centres from the start of the learning programme.

Candidates who fail the occupational specialism following the first submission can re sit in any assessment window.

Please note that for externally set assignments City & Guilds provides guidance and support to centres on the marking process and associated marking grid in the assessment pack for the qualification, and in the Guidance on the use of marking grids.
6 Grading

A grade
To achieve an ‘A’ grade a candidate will:

Show clear ability to demonstrate a comprehensive understanding of the full range of principles that influence construction processes and procedures in routine contexts and allow successful implementation to non-routine contexts.

Make links between relevant knowledge and understanding when responding to problems in a logical and methodical format. Legitimate and justified approaches are provided in response to complex construction industry briefs and problems.

Demonstrate the ability to comprehensively identify and interpret a full range of considerations in analysing complex briefs or problems. Including the impacts their decisions have on the wider industry and not solely on individual trades. There is a meticulous approach in the selection of tools, materials and methods when planning approaches or responses to construction industry briefs or problems.

Use a range of communication strategies and an ability to adapt their style and format to respond well to audience and stakeholder needs in presenting approaches to solving problems.

Demonstrate a high degree of accuracy in knowledge and skills from across the core content and critically evaluate their own performance in meeting a brief or problem to improve.

E grade
To achieve an ‘E’ grade a candidate will:

Demonstrate a limited understanding some of the key principles and how they influence construction process and procedures in routine contexts.

Make general links in knowledge and understanding that can sometimes be superficial and are supported by partial reasoning and not evidenced based that relates to routine problems or industry briefs.

Respond to briefs or problems with little awareness of the impact in relation to the wider construction industry context. There is some understanding in selection of tools, materials and methods to meet the requirements of routine construction industry briefs or problems.

Demonstrate a small range of communication strategies that are sometimes not suitable in language and format for audiences and stakeholders with inaccuracies in technical references.

Provide an evaluation of performance and how requirements have been met is brief with no reference on how to improve.
7 Administration

Lost candidate work
If work is lost, City & Guilds should be notified immediately of the date of the loss, how it occurred, and who was responsible for the loss. Centres should use the JCQ form, JCQ/LCW, to inform City & Guilds Customer Services of the circumstances.

Learners who move from one centre to another during the course may require individual attention. Possible courses of action depend on the stage at which the move takes place. Centres should contact City & Guilds at the earliest possible stage for advice about appropriate arrangements in individual cases.

Malpractice
Please refer to the City & Guilds guidance notes Managing cases of suspected malpractice in examinations and assessments. This document sets out the procedures to be followed in identifying and reporting malpractice by candidates and/or centre staff and the actions which City & Guilds may subsequently take. The document includes examples of candidate and centre malpractice and explains the responsibilities of centre staff to report actual or suspected malpractice. Centres can access this document on the City & Guilds website.

Examples of candidate malpractice are detailed below (please note that this is not an exhaustive list):

- falsification of assessment evidence or results documentation
- plagiarism of any nature
- collusion with others
- copying from another candidate (including the use of ICT to aid copying), or allowing work to be copied
- deliberate destruction of another’s work
- false declaration of authenticity in relation to assessments
- impersonation

These actions constitute malpractice, for which a penalty (e.g. disqualification from the assessment) will be applied.

Where suspected malpractice is identified by a centre after the candidate has signed the declaration of authentication, the Head of Centre must submit full details of the case to City & Guilds at the earliest opportunity. Please refer to the form in the document Managing cases of suspected malpractice in examinations and assessments.
Accessibility
In the design of the Technical Qualification and its assessments the following principles have been applied:

- In the development of content, tasks and assessments all learners are considered
- Well-designed materials that do not create barriers to attainment. This will include content being presented logically and uncluttered
- No particular characteristic or group of learners are disadvantaged by features of a qualification
- Language is appropriate including carrier language which is presented in its simplest for fair access to all learners
- In the design of content and assessments the impact on learners social, behavioural and emotional well-being will be considered
- Physical and sensory needs of learners in accessing content and assessments.

Access arrangements
Access arrangements are adjustments that allow candidates with disabilities, special educational needs and temporary injuries to access the assessment and demonstrate their skills and knowledge without changing the demands of the assessment. These arrangements must be made before assessment takes place.

It is the responsibility of the centre to ensure at the start of a programme of learning that candidates will be able to access the requirements of the qualification.

Please refer to the JCQ access arrangements and reasonable adjustments and Access arrangements - when and how applications need to be made to City & Guilds for more information. Both are available on the City & Guilds website:

Special consideration
We can give special consideration to candidates who have had a temporary illness, injury or indisposition at the time of the examination. Where we do this, it is given after the examination.

Applications for either access arrangements or special consideration should be submitted to City & Guilds by the Examinations Officer at the centre. For more information please consult the current version of the JCQ document, A guide to the special consideration process. This document is available on the City & Guilds website:
8 Components

Content of components
The components in this qualification are written in a standard format and comprise the following:

- City & Guilds reference number
- Title
- Level
- Guided learning hours (provisional)
- Assessment method
- Introduction section
- Underpinning knowledge outcome – including range and depth sections
- What learners need to learn
- How will this benefit learners when working in industry or progressing to further study?
- Links to maths, English and digital skills
- Guidance for delivery
- Suggested learning resources
- Mapping to apprenticeship standards *

* NB to be added post milestone 2
# Building services engineering core

**Level:** 3  
**GLH:** 520 (tbc)  
**Assessment method:** Knowledge test, Employer-set project

## What is the component about?

This component focuses on the learner’s knowledge and understanding of contexts, concepts, theories and principles relevant to on-site construction and Building Services Engineering (BSE). The component is designed to raise learners’ awareness of the industries and develop knowledge and understanding of:

- Fundamental Health & Safety practices associated with carrying out construction and BSE work
- Scientific principles related to construction activities
- The construction industry and careers within it
- Principles of sustainability and design, relevant to construction projects
- Information, data and principles of measurements
- Tools, equipment and materials used in BSE work
- Legislation, regulations and approved standards that apply to BSE systems.

Learners may prepare by asking themselves questions such as:

- How are teams of different specialists co-ordinated to work together on construction projects?
- What are different career pathways and destinations within the construction industry?
- What factors influence whether construction projects are profitable?
- What kind of tasks does a building service engineers perform?
- What systems do Building Service Engineers work on?
- What tools and equipment building service engineers use as part of their role?
Underpinning knowledge outcomes

On completion of the BSE Core, learners will understand

1. Health and safety
2. Construction science principles
3. Construction design principles
4. Construction and the built environment industry
5. Sustainability principles
6. Measurement principles
7. Building technology principles
8. Information and data principles
9. Relationship management in construction
10. Digital technology in construction
11. Construction commercial/business principles
12. Building Services Engineering (BSE) systems
13. Maintenance principles
14. Tool, equipment and materials

Completion of the BSE core will give learners the opportunity to develop their Maths, English and Digital Skills. Details are presented at the end of each specification.
BSE Core content

1. Health and safety
Criteria

1.1 Construction legislation and regulations.

Range:
Legislation and regulations - Health and Safety at Work Act (HASAWA), Reporting Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR), Control of Substances Hazardous to Health (COSHH), Construction (Design and Management) (CDM) regulations, Provision and Use of Work Equipment Regulations (PUWER), manual handling operations regulations, Personal Protective Equipment (PPE) at work regulations work at height regulations, control of noise at work regulation, environmental regulations, waste management, manufacturers safety data sheets, Electricity at Work Regulations, control of vibrations at work regulations, Confined Spaces Regulations, Management of the Health and Safety Act Regulations, lone working, BS7671

What do learners need to learn?
How current legislation listed can impact on the employer, employee and construction projects within a domestic and commercial setting.

Be aware of the implications of not adhering to the legislation listed on the public, client, business and employers.

The difference between statutory and non-statutory legislation, where each legislation is applicable in terms of construction activities. Who is responsible for maintaining legislation and the process of consultation and updating.

Regulations and the overarching guidance documents for working in the building services engineering sector including the activities and procedures they cover.

1.2 Public liability and employer’s liability.

What do learners need to learn?
What liability is and what the current requirements are relating to public and employer liability for construction employees and employers.

The implications of public liability such as, legal action and compensation and employer’s liability such as compensation, medical cost, legal costs and loss of income

Skills
CSB
EC5

Skills
EC5
1.3 Approved construction **codes of practice.**

**Range:**
**Codes of practice** - L5 control of substances hazardous to health, L8 legionnaires’ disease, the control of legionella in water systems.


Approved Code of Practice and guidance, L64 Safety signs and signals: the Health and Safety (Safety Signs and Signals) Regulations.


Guidance on regulation, L 80 a guide to the Gas Safety (Management) Regulations 1996.


Approved code of practice, regulations and guidance, L 102 Construction (Head Protection) Regulations 1989, L 108 controlling noise at work, L113 Safe use of lifting equipment.


**What do learners need to learn?**
The purpose of the codes of practice and how these are applied in terms of managing Health and Safety in the Construction industry. How to gain access to the listed publications.

| Skills | EC5 |
1.4 Development of **safe systems of work**.

**Range:**

**Safe systems of work** - company management systems, risk assessments, method statements, permits to work, safety notices and CSCS cards

**What do learners need to learn?**

Current safe systems of work used in construction projects. Roles and responsibilities, recording and reviewing and any potential implications of not having systems in place

**Skills**

| EC3 | EC5 |

1.5 **Safety conscious procedures**

**Range:**

**Safety conscious procedures** - safe systems of work, reporting of potential hazards, site inductions, training, toolbox talks, good housekeeping (working systematically, keeping areas clean and clear)

**What do learners need to learn?**

Procedures that aim to promote and support safety consciousness within construction sites/environments/workshop areas.

The benefits of having these procedures in place and the potential implications of not adhering to them – (i.e. injury/death, loss of business, fines, increased costs, project timescales slipping etc.)

**Skills**

| EC1 | EC3 |

1.6 **Safety inspection** of a work environment.

**Range:**

**Safety inspection** - sensory inspections, visual inspections, risk assessments, method statements, permits to work

**What do learners need to learn?**

The methods used to inspect a workplace to ensure it is safe for work — the documentation to complete, technical terms used and how to mitigate any risks.

**Skills**

| CSA | CSC | EC3 |
1.7 **Implications** to those working within the BSE industry of not following health and safety legislation.

**Range:**

**Implications** - penalties, improvement notice, prohibition notice, powers of prosecution

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roles and responsibilities and the consequences of not carrying out own role and responsibilities for those working within the BSE industry i.e.</td>
</tr>
<tr>
<td>• Employer</td>
</tr>
<tr>
<td>• Employee</td>
</tr>
<tr>
<td>• General Public</td>
</tr>
<tr>
<td>• Health and Safety Executive</td>
</tr>
</tbody>
</table>

1.8 Safe working practices for the safe isolation of **systems**.

**Range:**

**Systems** - Water supplies, gas supplies, electrical supplies

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The methods used to safely isolate various services/ systems that will be encountered whilst working in the Building Services Industry.</td>
</tr>
<tr>
<td>Safe working practices including warning notices, locking off devices, timescales for completion and continuation of services (back up) that are used while services are isolated</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Skills</th>
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</thead>
<tbody>
<tr>
<td>CSC MC10</td>
</tr>
</tbody>
</table>

1.9 **Implications** of poor health and safety on building performance and individual stakeholders.

**Range:**

**Implications** - Accidents, injuries, fatalities, slips, trips, falls, down time, financial, reputation, environmental, near misses

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The consequences of not working safely on site to individual stakeholders.</td>
</tr>
<tr>
<td>The implications of poor health and safety and who these impacts at different levels i.e. employee, employer/business, client/customer/public.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Skills</th>
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</tbody>
</table>
1.10 **Recording and reporting** of safety incidents and near misses.

**Range:**
\*Recording and reporting* - Accident book, reporting procedure, accident and Incident Reporting policy, RIDDOR reportable incidents

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The correct process to undertake and follow when reporting an incident or near miss in the workplace</td>
<td>CSA, CSD, EC3</td>
</tr>
</tbody>
</table>

1.11 **Emergency procedures** for unsafe situations

**Range:**
\*Emergency procedures* - Gas Industry Unsafe Situations Procedure (GIUSP), Gas Safety Installation and Use Regulations (GSIUR), Evacuations, electric shock, first aid.

**Unsafe situations** - Fire, gas leaks, terrorist threats, water leak, carbon monoxide, potential electric shock

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The correct procedures to follow if unsafe situations occur in the workplace. Actions to be taken when dealing with fire situations including groups of fire extinguisher and their use</td>
<td>CSC, EC5</td>
</tr>
</tbody>
</table>

1.12 **Types of PPE.**

**Range:**
\*Types of PPE* - Head protection (safety hat, bump cap, snood), eye protection (goggles, safety glasses, full face visor), ear protection (ear defenders, ear plugs), full body protection (overalls, workwear, elbow pads), hand protection (gloves, gauntlets), knee protection (knee pads, kneeling mat), safety footwear (safety shoes, safety boots, safety trainers), respiratory protection (respirators, dusk mask, face fit), vibration protection, harnesses

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The purpose and correct use of appropriate PPE to mitigate risks.</td>
<td></td>
</tr>
</tbody>
</table>
1.13 First aid facilities

**What do learners need to learn?**
The first aid facilities that must be available in the work area in accordance with Health and Safety regulations.

1.14 warning signs for the seven main groups of hazardous substance

**What do learners need to learn?**
The meaning of each pictogram in the CLP Regulation and where they would be encountered.

1.15 safe practices and procedures for the use of access **equipment**

Range:
**Equipment** - Access equipment (PASMA requirements) Ladders mobile scaffold towers, platforms, trestles, steps, podiums, staging, boom and scissor lifts

**What do learners need to learn?**
The safe practices and procedures for the safe erection and use of the range of access equipment including factors that influence selection
2. Construction science principles

Criteria

2.1 International System of **Units** (SI).

**Range:**
**Units** - Kilogram (mass) kg, second (time) s, hour (time) h, Kelvin (temperature) k, Pascal (pressure, quantity internal pressure) Pa, bar (Unit of pressure), energy – Joules (J), power – Watt (W), force - Newton (N), litres (l), Candela (cd) (unit of luminous intensity), Illuminance (Lux) (unit of illumination).

**What do learners need to learn?**

The Internationally recognised (SI) units of measurement and their application and use in building services engineering calculations including multiples and sub-multiples.

**Skills**

| MC1 |

2.2 Derived SI units.

**Range:**
**Derived SI units** - area (m²), volume (m³), flow (l/s and m³/h), density (kg/m³), velocity (m/s), specific heat capacity (kJ/kg/°C), acceleration (m/s²), volt, ampere, ohm.

**What do learners need to learn?**

All derived SI units and their application and use in building services engineering including those associated with area, volume, weight, power, energy and force.

**Skills**

| MC2 |

2.3 Materials science principles.

**Range:**
**Materials** – pure metals, ferrous metals, alloys/solders, thermos setting plastics, fireclays/ceramics.

**Principles** - material properties, chemical composition, degradation, failure, effects of environmental conditions.

**What do learners need to learn?**

The principles of material science in construction design and how buildings will perform in terms of durability and stability.

Environmental conditions to include: atmospheric corrosion, oxidation of metals, UV damage to plastics, heat damage to plastics, electrolytic corrosion, electromotive series, dissimilar metals in the presence of an electrolyte (water) erosion corrosion.

**Skills**

| CSB  
| MC4 |
### 2.4 Mechanical science principles.

**Range:**

**Mechanical science principles** - force, work, energy, power, levers, simple mechanics, basic mechanics.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key principles of Mechanical Science and how they are used to inform construction methods and the relationship between force, work energy and power and efficiency.</td>
<td>MC4</td>
</tr>
<tr>
<td>Simple mechanics to include: theory of moments, action and reaction, centre of gravity, equilibrium, velocity and ratio, mechanical advantage.</td>
<td></td>
</tr>
<tr>
<td>Simple mechanics to include: levers, pulleys, archimedes, screw.</td>
<td></td>
</tr>
</tbody>
</table>

### 2.5 Electricity principles.

**Range:**

**Electricity principles** - sources of power, generation, transformation, distribution, voltage, current, resistance, electrical power, energy, efficiency.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The various uses of electricity within the built environment including basic DC circuit principles, ohms law and relationships between circuit values.</td>
<td>MC4</td>
</tr>
</tbody>
</table>

### 2.6 Structural science principles.

**Range:**

**Structural science principles** - forces, loads, materials, structural members.

<table>
<thead>
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<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural science principles its use and effects in the construction of buildings.</td>
<td>CSB MC4</td>
</tr>
</tbody>
</table>
2.7 Heat principles.

Range:
Heat principles - heat transfer, air temperature, air density humidity, condensation air movement, heat loss, thermal conductivity, resistance, convection cycles.

What do learners need to learn?
Key principles of heat transfer and how it is used within the built environment.  
Skills  
MC4

2.8 Light principles.

Range:
Light principles - refraction, difference in artificial and natural light, glare, directed and reflected light, flow of light energy, daylight factor, colour rending.

What do learners need to learn?
Key principles of natural and artificial light and its relationship with the built environment.  
Skills  
MC4

2.9 Acoustics principles.

Range:
Acoustics principles - frequencies, reverberation, decibels, comfort levels, privacy.

What do learners need to learn?
How are key principles of acoustics and acoustic barriers are applied to the built environment.  
Skills  
MC4

2.10 Earth science principles.

Range:
Earth science principles - physical geography, hydrology, geology, earth forces, natural phenomenon (e.g. earthquakes, subsidence), weather.

What do learners need to learn?
How earth science principles influence the built environment and basic construction design principles.  
Skills
3. Construction design principles
Criteria

3.1 Benefits of good design.

Range:
Benefits - aesthetics, longevity of building, maintenance factors, on – budget.

**What do learners need to learn?**
The benefits of good design, the potential implications of poor design and the different parties affected in the construction chain.

Factors that can impact on the profitability of projects – i.e. over specification leading to higher costs, difficulty of assembly leading to increased timescales and increased budgets.

**Skills**
CSC
MC9
MC10

3.2 Design principles.

Range:
Design principles - Environmental Protection, safety, speed, economics, aesthetics, buildability manufacture, installation and construction feasibility, integration of services, infrastructure, inclusivity, accessibility, heat, acoustics, lighting and air quality.

**What do learners need to learn?**
Factors that need to be considered during the design of building services and how the range of design principles are influenced by the end design including buildability.

The stages and outcomes of the RIBA plan of work.

**Skills**
DC1
DC6

3.3 Role of different disciplines involved in design.

Range:
Disciplines - contractors and all operatives, architects and all professional occupations, planners and building inspectors, manufacturers

**What do learners need to learn?**
A basic knowledge of key job roles within construction design including the responsibilities and reporting lines/lines of escalation within roles.

The key activities aligned to the disciplines with an appreciation of potential career progression routes.

**Skills**
CSB
CSD
3.4 Design process from conception to completion.

Range:
Process - research, site analysis, assessment of current and proposed characteristics, planning, approval/ review, design sign off.

What do learners need to learn?
The key stages of the design process from initial enquiry to completed design and factors that may impact or influence design changes.

Skills
CSA

3.5 The concept of the ‘whole building’, including life cycle assessment.

Range:
Life cycle assessment - raw material supply, manufacture of construction products, the construction process stage, occupation, demolition, when the materials are disposed of or recycled.

What do learners need to learn?
The concept of the building services and how design and construction is influenced by building systems working together, including life cycle assessments and how they influence project planning and are influenced by regulations and legislation.

Skills
4. Construction and the built environment industry

Criteria

4.1 Structure of the construction industry.

What do learners need to learn?
The structure of the construction industry, including business types (e.g. sole traders, contractors, small, medium and large organisations).
The role of building regulators and the relationship with the customer/client.
The different scales of building project and types of development i.e. commercial, residential, private and public. Scale and size in determining who is involved.

Skills
MC3

4.2 How the construction industry serves the economy as a whole.

What do learners need to learn?
How the construction industry contributes to the UK economy with reference to scale.
Factors that impact growth of the industry, including political changes, developments in technology/practice skilled labour resources and environmental considerations.

Skills
MC3

4.3 Integration of the supply chain through partnering and collaborative practices.

Range:
Supply chain – client, architect, engineers, building contractor, sub-contractors, operatives, manufacturers, suppliers.

What do learners need to learn?
The integration of all partners of the supply chain in the building process. Be aware of the importance of effective planning and collaborative working ensuring that the project is completed to standards, budget and on time and the consequences of poor planning and communication.

Skills
CSD
4.4 Procurement of projects within the construction sector.

**Range:**
**Procured** - need/demand, tendering and bidding processes, supply chain, estimation, quotation, tender documentation.

**What do learners need to learn?**
The key stages within procurement and the development of construction projects with consideration of different scales of building projects from domestic through to commercial and industrial.

**Skills**
MC3

4.5. Managing change requests from various parties.

**What do learners need to learn?**
The basic principles of change requests from various parties, including clients and how the changes requested are dealt with (accurate, timely, professional) along with all impacts assessed and managed correctly.

**Skills**
CSC DC3

4.6 Roles and responsibilities of the construction professions.

**Range:**
**Construction professions** - architect, civil engineer, craft operative, ground works, plant occupation, non-skilled operative, building services design engineer, building services engineer technician, building services engineer site management, facilities manager, client representatives, contract managers.

**What do learners need to learn?**
The key job roles and responsibilities of construction professionals within construction industry listed in the range.

**Skills**
4.7 The role of CPD in developing the knowledge and skills of those working in the sector.

**Range:**
**Role of CPD** - upskilling staff, legal requirements, product knowledge.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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</thead>
<tbody>
<tr>
<td>The role of CPD to individuals, companies and the building industry as a whole.</td>
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<tr>
<td>It’s importance in maintaining currency and best practice, and the link to keeping clients/customers/public safe.</td>
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<tr>
<td>CPD and career progression. Providers of CPD i.e.</td>
<td></td>
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<tr>
<td>• Professional bodies</td>
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<tr>
<td>• Accreditation</td>
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<tr>
<td>• Certification bodies.</td>
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<tr>
<td>• Manufacturers</td>
<td></td>
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<tr>
<td>• In house/ toolbox talk</td>
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</table>

4.8 Building information modelling (BIM)

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The aspects of building information modelling and the effect they have on real time project delivery in a collaborative way.</td>
<td>CSD</td>
</tr>
<tr>
<td>BIM government levels 1-3.</td>
<td></td>
</tr>
<tr>
<td>The collaborative role of building information modelling in delivering real time projects:</td>
<td></td>
</tr>
<tr>
<td>• Digital Plan of Works (DPoW)</td>
<td></td>
</tr>
<tr>
<td>• Employer’s Information Requirements (EIR)</td>
<td></td>
</tr>
<tr>
<td>• Common Data Environment (CDE)</td>
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</tbody>
</table>
### 4.9 **PESTLE** factors

**Range:**
**PESTLE** - political, economic, social, technological, legal, environmental.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current examples of <strong>PESTLE</strong> and how it is used for analysis in building services and construction projects.</td>
<td></td>
</tr>
<tr>
<td>The potential impact these factors have on current and future building projects e.g. changes post Grenfell, tax changes for self-employed, augmented reality and impacts of Building Regulations and compliance.</td>
<td></td>
</tr>
</tbody>
</table>

### 4.10 **Documentation** used in construction projects.

**Range:**
**Documentation:** Take off sheets, contracts, schedule of rates, estimates, quotations, delivery notes, purchase orders, bill of quantities,

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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</thead>
<tbody>
<tr>
<td>Documents used through the construction process, when each are used including their purpose.</td>
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</tbody>
</table>

### 4.11 Procedures for handing over projects to clients.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The procedure for handing over projects to client including contents and purpose of Operation and Maintenance manuals, demonstration of use and client understanding, guarantee periods, snagging.</td>
<td></td>
</tr>
</tbody>
</table>
5. Sustainability principles
Criteria

5.1 Sustainability when planning and delivering a construction project.

Range:
Planning - using renewable and recyclable resources, reducing energy consumption and waste, creating a healthy and environmentally friendly environment, protecting the natural environment.

What do learners need to learn?
The importance of sustainability in relation to the stages of project development. Including design, planning and delivery and across different types/scales of construction project as well as environmental protection.

The relevance of local sourcing, resource protection, re-use and refurbishment of materials.

5.2 Types of sustainable solutions.

Range:
Sustainable solutions - social, environmental, economic, human (habitability).

What do learners need to learn?
The different types of sustainable solutions listed in the range and how they are used to inform the building or development process.

5.3 Environmental legislation.

Range:
Environmental legislation - Environmental Protection Act, Climate Change Act, Clean Air Act, Water Act, Building Regulations, COSHH, WEEE, Hazardous Waste Act.

What do learners need to learn?
The obligations and responsibilities of employers and employees in relation to construction/maintenance activities and environmental protection measures including hazardous waste, material considerations, disposal methods, BOCs, PPE, user guide instructions, specific risk assessments.

Key requirements of environmental regulations that must be adhered to whilst working in the building engineering services industry.
5.4 Environmental performance measures.

Range:
Measures - source of materials, use of materials, energy source, energy consumption, water source, water consumption, radioactive waste, flexibility, durability and resilience, pollution and waste processing, transport, landscape and ecology, deconstruction and disposal.

What do learners need to learn?
The key environmental performance measures of building services and how they are considered during design and monitored during building operation times (such as drainage polluting water courses).

5.5 Principles of heritage and conservation.

Range:
Principles - protection through listed building, regular maintenance, understand history and construction methods, sensitive use of materials, repair to match existing.

What do learners need to learn?
Heritage and conservation considerations such as listed buildings, traditional buildings and maintenance of existing stock and how current regulations affect the selection of materials used for building services activities.

5.6 Lean construction.

What do learners need to learn?
The efficient use of materials/ types of materials that can be recycled or reclaimed. The techniques aimed at maximising value and minimising waste within the building services industry.
5.7 Waste management legislation.

Range:

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key requirements and duty of care of waste management legislation including which materials may contain hazardous waste.</td>
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<tr>
<td>Key requirements to include:</td>
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</tr>
<tr>
<td>• Waste carriers license</td>
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<tr>
<td>• Separation and recycling waste</td>
<td></td>
</tr>
<tr>
<td>• Exemptions</td>
<td></td>
</tr>
</tbody>
</table>

5.8 Waste management.

Range:
Waste management - Waste Management plan, waste segregation, recycling.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>All current and statutory waste management systems, the way they are used in the disposal of construction materials including hazardous or specialised waste disposal.</td>
<td></td>
</tr>
</tbody>
</table>

5.9 Energy production and energy use.

Range:
Energy - Wind, water (hydro), solar, nuclear, fossil fuels.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current UK energy production and use in relation to embodied energy along with current methods used to monitor energy use within a building/system.</td>
<td></td>
</tr>
</tbody>
</table>
5.10 **Renewable energy and energy conservation**

**Range:**

**Renewable energy** - Solar thermal (hot water) ground source heat pump, air source heat pump, water source heat pump, biomass, solar photovoltaic, micro-wind, micro-hydro, combined and micro-combined heat and power.

**Energy conservation** - rainwater and grey water recycling, heat recovery, energy efficient lighting, electric vehicle charging points, appliance efficiency ratings, Insulation materials for ductwork, pipework, building structure insulation.

### What do learners need to learn?

The different types of renewable energy and how they are used to improve energy efficiency in buildings.

The importance of efficient design and the use of innovative products and services during the process. The different heat insulation materials used for systems and buildings.

### Skills

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<thead>
<tr>
<th>What do learners need to learn?</th>
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</thead>
<tbody>
<tr>
<td>The different types of renewable energy and how they are used to improve energy efficiency in buildings.</td>
<td>MC6 DC1 DC6</td>
</tr>
<tr>
<td>The importance of efficient design and the use of innovative products and services during the process. The different heat insulation materials used for systems and buildings.</td>
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</tr>
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</table>

6.11 **Emerging technology measures**

**Range:**

**Emerging technology measures**

**Internet of Things (IoT)** - Building services system controls, smart meters, hubs/routers

**Control and monitoring systems** - Smart meters, building management system, automated controls, movement sensors.

### What do learners need to learn?

System controls and building monitoring systems (BMS) used to improve energy efficiency in buildings, the monitoring patterns of usage and the use of innovative products and services during the process.

Automated controls and settings to maximise efficiency and movement sensors used to switch building services on and off when required.

The environmental technologies that could be used along including devices connected via the Internet of Things (IoT).

### Skills

<table>
<thead>
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<tr>
<td>System controls and building monitoring systems (BMS) used to improve energy efficiency in buildings, the monitoring patterns of usage and the use of innovative products and services during the process.</td>
<td>MC6 DC1 DC6</td>
</tr>
<tr>
<td>Automated controls and settings to maximise efficiency and movement sensors used to switch building services on and off when required.</td>
<td></td>
</tr>
<tr>
<td>The environmental technologies that could be used along including devices connected via the Internet of Things (IoT)</td>
<td></td>
</tr>
</tbody>
</table>
6. Measurement principles
Criteria

6.1 Accurate and appropriate measurement.

What do learners need to learn?
The benefits of accurate measurements to contractors, the client/customer, to profitability and project success detailing the Implications of not having accurate measurements – in terms of costs, time, and safety.

Skills
CSC
MC1
MC9

6.2 Standard units of measurement and measurement techniques.

Range:
Units of measurement - mm millimetres, cm centimetres, m metres, km kilometres, g gram, kg kilogram, tn tonne, ltr litres, sq square and cm cubic metres.

Measurement techniques - Approximation, use of measuring equipment including tapes, lasers and surveying equipment

What do learners need to learn?
The types of units of measurement and how these are applied and used in construction projects including methods of obtaining measurements in differing situations (height, length, distance, area, volume, weight, mass, quantity).

Skills
MC1
MC2

6.3 Measurement standards, guidance and practice.

Range:
Measurement standards - scale, tolerances.

What do learners need to learn?
How to use standardised scales for recording or displaying measurements, including measurement rules.

How tolerances are applied and implications of not meeting tolerances. Why particular scales are selected and importance of showing detail.

Drawing sizes used to display information and detail.

Skills
MC1
MC3
MC4
7. Building technology principles
Criteria

7.1. Construction methods.

Range:
**Construction methods** - modular, on-site, off site, 1st fix, 2nd fix, self-driving vehicles, computer-controlled manufacturing robots, large-scale 3D printers, drones.

What do learners need to learn?
Applications, limitations procedures of both traditional and modern construction methods including the use of robotics during the construction process.

7.2 Forms of construction.

Range:
**Forms** - substructure, superstructure, foundation, roof (flat, pitched), shell and core, structural frame, floor.

What do learners need to learn?
Current forms of construction and their use for both built environment and civil engineering structures. Supports and fixings associated with forms in range and building services components.

7.3 Key content and required notifications of Building Regulations and **Approved Documents**.

Range:

What do learners need to learn?
The purpose of all current UK Building Regulations in renovations and construction of buildings and building services.

Skills

| CSB | EC5 |
7.4 Building standards

Range:


<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current British Standards, International Standards and construction industry guidance in both the renovation and construction of buildings, including ISO, British and industry.</td>
<td>EC5</td>
</tr>
</tbody>
</table>

7.5 Regulatory bodies and guidance on technical safety and legislative aspects.

Range:
Regulatory bodies - CIBSE – Chartered Institute of Building Services Engineers, BESA – Building Services Engineers, gas safe, CIPHE – Chartered Institute of Plumbing and Heating Engineers, APHC - Association of Plumbing and Heating Contractors, IET – Institution of Engineering and Technology.

What do learners need to learn?

The regulatory bodies and other sources of information and their responsibilities in relation to the BSE sector.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The regulatory bodies and other sources of information and their responsibilities in relation to the BSE sector.</td>
<td></td>
</tr>
</tbody>
</table>
7.6 Manufacturers’ instructions.

**What do learners need to learn?**

Typical contents of both manufacturer instructions and technical guidance that are used and how they are applied in the construction and maintenance of buildings and services.

**Skills**

CSA

7.7 Building **structure** and **fabric**.

**Range:**

**Structure** - Timber framed, steel framed, masonry, concrete.

**Fabric** - Timber, cladding, masonry, fenestration, plaster boarding.

**What do learners need to learn?**

The different types of building materials and building fabrics and the implications for the application, installation and maintenance of Building Services Engineering systems including supports, fixings and hazards.

**Skills**

CSA

7.8 **Approved documents and guidance** for penetrating building structure and fabric.

**Range:**

**Approved documents and guidance** - Part A - Structure, part B - fire safety, Part C - Site preparation and resistance to contaminates and moisture, part E - Resistance to the passage of sound

**What do learners need to learn?**

The procedures and processes for penetrating building structure and fabric for a range of services in compliance with the approved documents listed in the range.

**Skills**

CSA

EC5
8. Information and data principles

Criteria

8.1 Data.

What do learners need to learn?

Key elements of data, including accuracy, generalisation, interoperability, level of detail and metadata used to inform construction and building services processes.

Different sources that data can be generated from including,
- Design and construction processes
- Building Information Modelling
- Post occupancy evaluation
- Utilities, building services, meters, building management systems.
- Infrastructure and transport systems.
- Enterprise systems such as purchasing systems, performance reporting, work scheduling.
- Maintenance and replacement systems.
- Operational cost monitoring.
- ICT systems and equipment.

Data from these sources can be used to understand behaviour, assess performance, improve market competitiveness, and allocate resources.

Skills
- MC5
- MC6
- MC9
- EC4
- EC5
- DC3

8.2 Sources of information.

What do learners need to learn?

Be able to interpret types of information and data sources used within construction and building services projects:
- product data
- manufacturer’s specifications
- client’s specifications
- Common Date Environment
- BIM
- Gantt charts
- Critical path networks
- Certification and commissioning data
- Test data schedules
- Condition reports

Skills
- CSC
- EC1
- EC2
- EC3
- DC1
- DC3
8.3 **Data** management and confidentiality.

**Data** - physical storage, virtual storage.

**Confidentiality** - encrypted data, virus protection software, software updates, firmware updates, GDPR Requirements, business procedures.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current legislation including GDPR and organisational procedures that are used to manage data and increase confidentiality.</td>
<td>DC5</td>
</tr>
<tr>
<td>Data storage requirements in relation to security and protection and how they help to prevent common threats e.g. cyberattacks, malware, Trojans, data loss, data recovery.</td>
<td></td>
</tr>
</tbody>
</table>

8.4 **Drawings, circuit diagrams and schematics**.

**Range:**
**Drawings, circuit diagrams and schematics** - symbols, circuit diagram, wiring diagram, layout and schematic drawings, building/site plans.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpret Building Services Engineering information and data using scale, abbreviations and BS symbols. The conventions, symbols and terminology needed to aid interpretation.</td>
<td>MC3 MC6 MC7 DC1 DC2</td>
</tr>
</tbody>
</table>

8.5 Programming and set up of **digital systems** using various **IT resources**.

**Range:**
**Digital systems** - Smart controls, BIM, CAD

**IT resources** - modelling and design programmes, mobile technologies, computer, CAD catalogues.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic programming including the set up requirements of digital systems for BSE systems and which IT resources to use.</td>
<td>DC1 DC6</td>
</tr>
</tbody>
</table>
9. Relationship management in construction
Criteria

9.1 Stakeholders.

What do learners need to learn?
The different types of stakeholders including: client, team, suppliers and end user.

Skills
CSD

9.2 Roles, expectations and interrelationships.

What do learners need to learn?
The roles, expectations and interrelationships of all stakeholders throughout the construction project delivery e.g. at design stage, through construction, to handover and in use.
To include
  - Hierarchy of project management
  - Promoting good relationships across the project
  - Cost control measures
  - Time management methods
  - Handover processes
  - Public relations
  - Follow up and review

Skills
CSD

9.3 Collaborative working to project delivery and reporting.

What do learners need to learn?
The importance of a collaborative approach to project delivery and reporting, and how this is applied in practice with the use of BIM and workflow software packages as well as face to face methods.

Skills
CSC CSD EC1 EC2 EC3 DC3
9.4 **Customer service principles.**

**Range:**
**Customer service principles** - product knowledge, time, communication, honesty and integrity.

**What do learners need to learn?**
The basic principles of good customer service as listed in the range including product knowledge, good communication, accuracy, efficiency, respect and prompt responses during all stages of the project.

**Skills**
CSC
EC6

9.5 **Team work to team and project performance.**

**What do learners need to learn?**
The importance of team work to team and project performance and the consequence of poor teamwork and how it impacts on a construction project.

**Skills**

9.6 **Team dynamics.**

**Range:**
**Team dynamics** - accountability, cooperation, trust, support, reliability, communication, participation.

**What do learners need to learn?**
The principles of good team dynamics, including what is expected of a team member, what qualities are needed and how these qualities are demonstrated.

**Skills**
EC6

9.7 **Equality, diversity and representation.**

**Range:**
**Equality, diversity and representation** - age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex, sexual orientation.

**What do learners need to learn?**
current equality and diversity legislation and the protected characteristics detailed under the Equality Act including its application in the workplace.

**Skills**
9.8 Negotiation techniques.

Range:
Negotiation techniques - Distributive Negotiation or Win-Lose Approach, lose-lose approach, compromise approach, integrative negotiation or win-win approach.

What do learners need to learn?
Methods of negotiation which are used within the construction industry. Skills: EC6

9.9 Conflict management techniques.

Range:
Conflict management techniques - preventative measures, workplace changes, job role changes, training staff, conflict resolution policy, alternative dispute resolution (Informal discussions, mediation, conciliation, arbitration).

What do learners need to learn?
Conflict management techniques including preventative measures and common reasons for conflicts. Skills: CSD

9.10 Methods and styles of communication.

Range:
Methods - verbal (Face to face, telephone,), written (Email, Text, letter)

Styles - formal, informal.

What do learners need to learn?
The methods and styles of communication and their suitability for different situations that may arise throughout a typical construction project. Skills: EC1, EC3, EC6, DC1, DC3
9.11 Employment **rights and responsibilities**.

**Range:**
**Rights and responsibilities** - wage rules, dispute resolution, dismissal and redundancy, health and safety and welfare, the employment rights act, time off work, contract of employment.

**What do learners need to learn?**  
The current employment rights and responsibilities of both employees and their employer.

**Skills**

9.12 Ethics and **ethical behaviour**.

**Range:**
**Ethical behaviour** - honesty, integrity, loyalty, fairness, caring, respect, law abiding, commitment, morale, reputation, accountability.

**What do learners need to learn?**  
Ethics and ethical behaviour within the construction industry.

**Skills**

9.13 Sources of information.

**What do learners need to learn?**  
How sources of information, including social networking contribute to knowledge sharing within the construction industry.

**Skills**
10. Digital technology in construction
Criteria

10.1 Internet of things.

Range:
Internet of things - Smart Technology, smart/automated building, smart learning and of artificial intelligence (AI).

What do learners need to learn?
The use of technology to capture data in a completed building and how this data is used for the purpose of manufacture and delivery.
The different uses of technology connected to the internet of things and their role in the construction industry to assist in just in time and asset management.

Skills DC6 DC1

10.2 Digital engineering techniques.

Range:
Digital engineering techniques - Simulation, animation, virtual reality, 3D modelling.

What do learners need to learn?
Current Digital engineering techniques and their application in the construction industry.

Skills DC6

10.3 Opportunities for the use of technology used in other industries and contexts and adapting for use in construction and the built environment.

Range:
Technology - Machine manufacturing through robotics, CADCAM, computer modelling, smart technologies.

What do learners need to learn?
The use of current technologies from other industries and how they can be adapted for use in the construction and the built environment.

Skills DC1 DC6
11. Construction commercial/business principles

Criteria

11.1 Business structures.

Range:

**Business structures** - Sole Trader, partnership, Limited Company (PLC. Ltd.), SMEs, not for profit organisations, community interest companies.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical business structures that exist in the built environment and construction industry.</td>
<td></td>
</tr>
</tbody>
</table>

11.2 Business objectives.

Range:

**Business objectives** - revenue, social, brand, sales, customer experience, customer relationship, organisation culture, quality, innovation, compliance, sustainability.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The business objectives used to measure the performance of the organisation.</td>
<td></td>
</tr>
</tbody>
</table>

11.3 Business values.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The fundamental business values e.g. care for life, ethical and transparent, commit to customer and collaborative working.</td>
<td>CSD</td>
</tr>
</tbody>
</table>

11.4 Principles and examples of corporate social responsibility.

Range:

**Principles** - Community, people, customer, suppliers, environment.

**Examples** - Local recruitment, sustainable resourcing

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
11.5 **Principles** of entrepreneurship and innovation.

**Range:**
*Principles* - Solution provider, vision, viable product/service, capital, growth and marketing, research, priorities.

**What do learners need to learn?**
The basic principles of entrepreneurship and innovation in business.

11.6 Measuring success.

**What do learners need to learn?**
How organisations in the built environment and construction industry use benchmarking, KPI's and target setting when measuring business success

11.7 Project management.

**What do learners need to learn?**
The principles of project management including, setting clear goals and objectives, defining roles, setting realistic milestones and constraints on cost and time. Ensuring all objectives are measurable and achievable.

11.8 Quality management.

**What do learners need to learn?**
The quality management systems and techniques used in business including:

- Self-assessment
- Internal audit
- External audit
- Quality control
- Quality improvement
- ISO 9000
12. Building Services Engineering (BSE) systems
Criteria

12.1 Building Services Engineering systems.

Range:

Systems -

- Air conditioning system - cooling air, heating air, humidification.
- Electrotechnical system – power, data, lighting, control, heating, appliances.
- Gas systems – boilers, fires, cooking appliances.
- Heating systems – domestic, commercial, industrial.
- Plumbing systems – cold water, hot water, sanitation, rainwater systems.
- Protection systems – Intruder alarms, Surveillance systems, fire alarm, and access control.
- Refridgeration systems – chilled water, cooling air.
- Ventilation systems – mechanical ventilation, non-mechanical ventilation.

What do learners need to learn?

The layout and basic components included in a range of BSE systems. What these systems are used for and when they are used.

Key differences in operation and advantages and disadvantages of each system type. Integration between systems including common skills.

Skills

CSA
CSB

12.2 The potential effects on building performance during installation, commissioning and decommissioning of BSE systems.

What do learners need to learn?

The effects of installation, commissioning and decommissioning of all or part of a BSE system, including impact on:

- Environment
- other trades
- user such as loss of services or essential systems

Skills

12.3 Mechanical principles of components.

Range:

Components - fans, pumps, burners/ boilers, chillers, heat pumps, controls.

What do learners need to learn?

Basic mechanical principles of BSE components, detailing their characteristics, function within the system and implications to the system of component failure.

Skills
12.4 Electrotechnical principles of **components**.

**Range:**

**Components** - cable types, accessories, containment.

**What do learners need to learn?**  
Electrotechnical principles of components including their characteristics, applications and functions.

Advantages and disadvantages of each component and implications to the system if components fail.

**Skills**

12.5 **Electrical supply**.

**Range:**

**Electrical supply** - single-phase circuits, three-phase circuits, three-phase and neutral, balanced supplies.

**What do learners need to learn?**  
The different types of electrical supply.

The different voltage levels achieved between circuit conductors in electrical supplies in a range of buildings.

The benefits of having different voltages supplies and the voltage levels for Building services Engineering systems.

**Skills**

12.6 **Earthing arrangements**.

**Range:**

**Earthing arrangements** - TN-C-S (PME) systems, TN-S systems, TT system.

**What do learners need to learn?**  
The different types of earthing arrangements and the attributes of each system. The nature of the earth return path in each system and what system components are included in each arrangement.

Hazards associated with each system and how this impact on the different building services.

**Skills**
12.7 **Cable, accessories and equipment** used in older electrical installations.

**Range:**

**Cable, accessories and equipment** - lead sheathed cable, VIR-Vulcanized India Rubber insulated cable, cable colours, BS 3036 – re-wire able fuses, non-fire rated consumer units/distribution boards.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The common cable types and sizes (metric, imperial) for a range of circuits.</td>
<td>MC2 MC4</td>
</tr>
<tr>
<td>The various electrical accessories and equipment used in old electrical systems that are still in existence in electrical installations and the potential risks when working on or near.</td>
<td></td>
</tr>
<tr>
<td>How they have been superseded and the components they have been replaced with and the implications for Building Services Engineering system installation and maintenance.</td>
<td></td>
</tr>
</tbody>
</table>

12.8 Pipework and **ductwork, components** and **systems**.

**Range:**

**Systems** - gas, plumbing, air conditioning, refrigeration, heating, drainage.

**Ductwork** - flexible ducting, metal ducting, fabric ducting, cardboard ducting.

**Components** - ductwork accessories (e.g. VCD, VAV/CAV, fire dampers, attenuators, heating coils, cooling coils etc), air terminals (e.g. grilles, louvres, extract valves etc), electrical components (electrical Isolators), pipework accessories (emergency control valves, stop taps and key isolation valves, radiator valves, room thermostats).

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The various types of components that make up both pipework and ducting systems used in Building Services Engineering systems and how the selection of each affects the performance of the system.</td>
<td></td>
</tr>
</tbody>
</table>

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74
13. Maintenance principles
Criteria

13.1 Types of maintenance.

Range:
Types of maintenance - planned preventative maintenance, reactive maintenance.

What do learners need to learn?
- General types of maintenance their key differences and which is most suitable for different situations, including planned preventative maintenance.
- Regular maintenance scheduled to identify any possible maintenance required before the system fails and Reactive maintenance.
- Maintenance that is required because the system has already failed.

13.2 Maintenance plans.

Range:
Maintenance plans - heating system service, boiler service (Gas engineer), water services, firefighting equipment, fire detection and smoke alarm systems, intruder alarm system, wiring and electrical installation system, ventilation system, air conditioning system, drainage, lighting, communications and data.

What do learners need to learn?
- The requirements of maintenance plans, either as planned or reactive. Their content and typical tasks for Building Services Engineering systems.

13.3 Typical timeframes between maintenance tasks.

What do learners need to learn?
- The frequency for completing maintenance tasks on all BSE systems as listed in the range. e.g the requirements for landlord safety checks on systems such as gas appliances and electrical systems at regular intervals.
13.4 **Documentation** required for maintenance and verification of maintenance activities.

**Range:**
*Documentation* - manufacturer’s instructions, maintenance checklists, servicing logbooks, maintenance schedules, job sheets, condition reports.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The reference documents and forms needed when completing both planned and reactive maintenance.</td>
<td>EC4</td>
</tr>
</tbody>
</table>

13.5 **Actions** required when faults cannot be rectified.

**Range:**
*Actions* - inform customer, arrange secondary services until primary are back in service, make systems safe.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The actions required when faults cannot be rectified and the implications this can have on the customer and business:</td>
<td>MC2 MC9 EC1 EC3 EC4</td>
</tr>
<tr>
<td>• Time</td>
<td></td>
</tr>
<tr>
<td>• Costs</td>
<td></td>
</tr>
<tr>
<td>• Downtime of systems</td>
<td></td>
</tr>
<tr>
<td>• Loss of income</td>
<td></td>
</tr>
<tr>
<td>• Increase of hazards</td>
<td></td>
</tr>
<tr>
<td>• Loss of services</td>
<td></td>
</tr>
</tbody>
</table>
14. Tools, equipment, and materials

Criteria

14.1 Methods used to ensure tools, equipment and materials are fit for purpose.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The methods to ensure tools, equipment and materials are fit for purpose and the required checks that are undertaken to ensure this:</td>
</tr>
</tbody>
</table>

**Tools and equipment**
- PAT Testing
- Calibration of instruments
- Cleanliness checks
- Daily checks e.g. visual inspection, operation check
- Condition reports
- Asset registers

**Materials**
- Fit for purpose
- Associated hazards
- Quantity
- Specialist requirements

14.2 **Maintenance** of tools, equipment and materials.

**Range:**
**Maintenance** - safe storage, correct storage, greasing, sharpening, cleaning.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The importance of correct tool maintenance and the methods of maintaining a range of tools used in BSE, Including:</td>
</tr>
</tbody>
</table>

- Safety
- Prolonged tool life
- Accuracy

Skills

MC1
Links to occupational specialisms

All aspects of the BSE core content can be related and contextualised on delivery with the occupational specialisms. However, the following are key areas of the content that may be of particular relevance when delivering the practical content in the occupational specialisms and provide efficiencies for teaching core knowledge in context:

BSE specific core content

- Health and safety - BSE Regulations and safe working practices
- Building Services Engineering (BSE) systems
- Tools and equipment – Use and maintenance
- Construction sustainability principles
- Scientific principles
- Building technology principles
- Information and data principles

Guidance for delivery

- visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery.
- Formative assessment – oral Q&A, SmartScreen worksheets (samples available)
  
  o Practical - Use of pre-set formative assessments carry out tasks and record on standardised form.
  o Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT

- Ways of ensuring content is delivered in line with current, up to date industry practice
  o Centres will need to ensure a realistic representation of BSE systems and components are available
  o Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration
  o The provision must represent the type of equipment currently available in the UK BSE industry
  o Current and emerging BSE technology should be included in delivery where possible

Suggested learning resources

Books

- The City & Guilds Textbook: Plumbing Book 1 for the Level 3 Apprenticeship (9189), Level 2 Technical Certificate (8202) and Level 2 Diploma (6035) (City & Guilds)
- The City & Guilds Textbook: Plumbing Book 2 for the Level 3 Apprenticeship (9189), Level 3 Advanced Technical Diploma (8202) and Level 3 Diploma (6035) (City & Guilds)
- The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365) (City & Guilds Textbooks)
- The City & Guilds Textbook: Book 2 Electrical Installations for the Level 3 Apprenticeship (5357), Level 3 Advanced Technical Diploma (8202) & Level 3 Diploma (2365)
Websites

- Institute for apprenticeships and technical education  
  https://www.instituteforapprenticeships.org/
- Water Regulations https://www.wras.co.uk/
- Building Regulations portal  
  https://www.planningportal.co.uk/info/200128/building_control
- Gas Safe https://www.gassaferegister.co.uk/
- British Standards Institution  
  https://www.standardscentre.co.uk/?kw=british%20standards&ad=3470131973&gclid=EAIaIQobChMI2qvPv-iu5wlVA7DtCh2pDARmEAAYASAAEgKy_PD_BwE
- Chartered Institution of Building Services Engineers https://www.cibse.org/
- Approved Plumbing and Heating contractors https://www.aphc.co.uk/
- Electrical http://www.niceic.com/
351  Air conditioning engineering

<table>
<thead>
<tr>
<th>Level:</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLH:</td>
<td>440 (tbc)</td>
</tr>
<tr>
<td>Assessment method:</td>
<td>Practical assignment</td>
</tr>
</tbody>
</table>

What is this specialism about?
The purpose of this specialism is for learners to know and undertake fundamental air conditioning work. Learners will have the opportunity to plan, perform and evaluate their work whilst utilising a range of materials, methods and techniques.

Learners will develop their knowledge and understanding of, and skills in:
- Installing, commissioning and maintaining air conditioning systems
- The hazards and health and safety requirements when working on air conditioning systems
- Identifying and selecting the correct tools and equipment for a specific task
- Fabricating and pressure testing pipe work to ensure it is leak-free
- Fault-finding mechanical and electrical problems in air conditioning systems

Learners may be introduced to this specialism by asking themselves questions such as:
- How does an air conditioning technician achieve a leak-free system?
- What are the requirements of the F-Gas regulations?
- What tools and equipment does an air conditioning technician need?

Underpinning knowledge outcomes
On completion of this specialism, learners will understand:
1. Air conditioning knowledge criteria

Performance outcomes
On completion of this specialism, learners will be able to:
2. Install air conditioning systems
3. Commission air conditioning systems
4. Maintain air conditioning systems

Completion of this specialism will give learners the opportunity to develop their Maths, English and Digital Skills. Details are presented at the end of the specification.
Specialism content

Common knowledge criteria

Air conditioning systems
1.1 The function and operation of air conditioning systems.

Range:
Air conditioning systems - Direct expansion, flooded, (centralised plant, Air Handling Units (AHUs), fan coils, chilled beams) heat pump (ground, air and water source), VRV/VRF air conditioning, water chillers.

What do learners need to learn? The function and operation of air conditioning systems currently in use and how they interact in different systems and applications.

1.2 The uses of air conditioning and ventilation in a modern economy.

What do learners need to learn? The uses of air conditioning and ventilation including the difference between cooling for human comfort and for process control in industry.

Air conditioning science
1.3 Scientific principles of air conditioning.

Range:
Scientific principles - thermodynamics, gas laws, psychrometrics, fluid flow, electricity, filtration, heat transfer, properties of refrigerant fluids and lubricants.

Principles of thermodynamics -
- Temperature scales (Celsius, Kelvin)
- Laws of thermodynamics (First law, second law)
- Heat transfer (Conduction, convection, radiation)
- Latent heat processes (Melting (Fusion), freezing, sublimation, condensation, evaporation, boiling)
- Sensible heat processes (Super heating, sub-cooling)

Ideal gas laws - Boyle’s law, Charles’ law, Combined gas law, Dalton’s law, Units of pressure (Pascal, Bar, Millimeters of Hg, Torr), Pressure scales (Absolute, vacuum, gauge).
Primary refrigerants - HFC, HFO, HC, Natural refrigerants

- Primary refrigerant ideal properties:
- Secondary refrigerants:
- Secondary refrigerant ideal properties:
- Environmental impact:
- Ideal Properties of lubricants:

Filtration - Air filter (panel, bag, HEPA, carbon), water, refrigerant.

Psychometrics - Properties of air: Physical make-up, moisture content, temperature
Measuring devices: Sling psychrometer, hygrometer.

Psychrometric chart plot points: Wet bulb temperature, dry bulb temperature, percentage saturation, moisture content, specific volume, enthalpy, dew point, apparatus dew point.

Psychrometric processes: sensible, latent.

Range of variables and calculations - Cooling capacity, heating capacity, quantity of condensate over time.

Pipe characteristics: (Diameter, length, bends, fittings, orientation, equation of continuity)
Impact on system performance: (Flash gas, oil return, velocity, saturation temperature, mass flow rate, cooling/heating capacity, refrigerants, operating temperatures and pressures, efficiency, pressure drop vs velocity).

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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<tbody>
<tr>
<td>The principles of air conditioning science and how they apply to real life situations e.g. (gas laws and pressure testing, psychometrics and commissioning, heat calculations and heat transfer in system evaluation).</td>
<td>MC2 MC6</td>
</tr>
</tbody>
</table>

1.4 Comfort in terms of temperature, humidity, carbon monoxide, metabolism.

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<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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</thead>
<tbody>
<tr>
<td>The principles of air quality and its effect on human comfort. The Properties of air, physical make up, humidity and water content, effect of pollutants, human comfort, air temperature (dry and wet bulb).</td>
<td>MC2 MC6</td>
</tr>
</tbody>
</table>
1.5 Types of data.

Range:
Data - Measurements, diagrams, calculations, tools, charts, tables

Measurement:
- **Base units** - Metre (length) m, kilogram (mass) kg., second (time) s., Kelvin (temperature) K, ampere (electrical current) A.
- **Derived units** - Area (m²), volume (m³), litres (L), density (kg/m³), velocity (m/s), acceleration (m/s²), pressure (Pascal), specific volume (m³/kg) energy (J), enthalpy (kJ/kg), conductivity (W/mk), energy rate (W).
- **Cooling and heating formulae** - \( Q = mCt, Q = mL, Q/s = W \).
- **Tools, charts and tables** - Refrigerant Comparators (slides and apps), psychometric charts.
- **Calculations** - Pressure calculations (static and dynamic) \( P = hpg, P = 1/2pv^2 \), room heat gain calculation.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
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<tbody>
<tr>
<td>Types and data and how to apply them. The SI system of measurement and methods to apply to a range of calculations.</td>
<td>MC4 MC6 MC7</td>
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</table>

Legislation, Regulations and Standards

1.6 Relevant UK and international standards and Approved Codes of Practice (ACOPS).

Range:

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
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<tbody>
<tr>
<td>Current health and safety and environmental legislation that apply to all aspects of the air conditioning industry. Relevant UK and international standards, Approved Codes of Practice (ACOPS) related to air conditioning systems including indoor air quality, bacteria in water and asbestos.</td>
<td>EC4 EC5</td>
</tr>
</tbody>
</table>
1.7 Environmental technologies employed in the sector.

Range:
Environmental technologies - cross-flow heat exchangers, thermal heat recovery wheels, run-around coils, capacity controls, inverter control.

What do learners need to learn?  
The various energy efficiency methods used to reduce power consumption and environmental impact, reducing heat gain, cooling load or energy use.

1.8 Supply and storage of energy from renewable resources.

Range:
Renewable resources - wind power, solar power, photovoltaic, hydroelectric, biofuels, tidal power, battery storage, waste to energy projects.

What do learners need to learn?  
Supply and storage of energy from a range of renewable energy sources.

1.9 Reducing environmental impact of air conditioning systems through circular economics and low impact refrigerants.

What do learners need to learn?  
Low GWP refrigerants and renewable energy and heat recovery and how they reduce the carbon footprint of an air conditioning system to include an overview of renewable source energy, heat recovery, low GWP refrigerants (HFO, HC, natural refrigerants).
### System Installation (PO1)

1.10 How to check multiple circuits and systems for leakages.

**What do learners need to learn?**

How the F-Gas regulations, BS EN378 and the application of gas laws, relate to pressure testing and leak testing and the techniques for the safe pressure and leak testing of a system.

1.11 Location methods for air handling system installation including types of **tools and equipment** needed.

**Range:**

**Tools and equipment** - Wall/ceiling fixings, pipe benders, brazing equipment (LPG, oxy-acetylene), pipe fittings, mechanical (flare, compression fittings) and braze jointing of pipe work.

**What do learners need to learn?**

The methods and types of fixings used in the construction industry and how they can be used to mount air conditioning equipment. The different types of pipe jointing methods and when one should be used as opposed to the other (DSEAR regulations).

1.12 Types of **ductwork** and **pipework**.

**Range:**

**Ductwork** plastic, steel, rectangular, circular, oval, rigid, flexible.

**Pipework:** Copper, steel, aluminum, plastic.

**What do learners need to learn?**

The different types of duct and pipes used in the RAC industry and when different types would be applied (pressure rating, space available). The different Materials used in ductwork - steel, aluminum plastic.
1.13 **System operation requirements** to be checked for commissioning.

**Range:**
**System operation requirements** - Running pressures, temperatures, superheat, sub cooling, running current, refrigerant charge, leak testing.

**What do learners need to learn?**
The System data, measurement and observations that are taken when commissioning a system and how data should be used in order to achieve maximum energy efficiency and design set conditions.

**Skills**
- MC1
- MC6

1.14 **Visual inspection** of an air conditioning system.

**Range:**
**Visual inspection** - Senses (sight, touch, hearing, smell).

**What do learners need to learn?**
How to use the human senses to determine fault conditions. The process of carrying out a visual inspection and what factors are to be checked - Wear and tear, excessive vibration, oils traces (refrigerant leak).

**Skills**
- MC2

1.15 **Expectations of a steady state operation for air conditioning systems.**

**What do learners need to learn?**
Design parameters and steady state conditions for different cooling applications to determine the correct operating conditions. How to determine the optimum running pressures and temperatures of an air conditioning system to meet the design parameters.

**Skills**
- MC1
- MC6
1.16 Types of fault-finding techniques.

Range:
Fault finding techniques - Use of senses, previous site reports, customer information, commissioning data

What do learners need to learn?

Fault finding techniques and how these are applied in practice.

The suitability of different fault finding techniques for different situations.

The importance of comparing previous commissioning data to current data to identify faults, running conditions to determine if a fault condition exists.

The use of senses (sight, sound, touch, smell), manufacturer’s instructions and fault codes, historical operating and commissioning data to determine and identify a fault condition.

Skills
MC2
MC6

1.17 Cleaning of components.

Range:
Cleaning - Coil cleaning fluids, spray washers.

Components – evaporator and condenser coils, drain pan, pump, drain lines.

What do learners need to learn?

Process for safe isolation of an air conditioning system electrically. The correct PPE and correct cleaning fluid for each component to ensure system is not compromised.

Spray wash the evaporator and condenser coils and clean the drain pan, pump and drain lines using the correct cleaning fluid for each component tools, equipment and materials to do that.

Skills

1.18 Disassembly techniques.

What do learners need to learn?

Process for safe isolation of the system electrically and the importance of following manufacturers recommendations, instructions and method statements to disassemble an air conditioning system ready for a repair activity.
1.19 **Techniques** according to use and operation of system.

**Range:**
**Techniques** - Preventative maintenance, reactive maintenance

<table>
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<tr>
<td>The difference between critical and non-critical systems, reactive and preventive maintenance situations and how to prioritise which fault-finding techniques must be used.</td>
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</table>

1.20 Referral of a fault to a specialist.

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<tbody>
<tr>
<td>How to determine if the fault-finding technique needs a specialist technician (F-Gas for charging and recovering refrigerant, electrician for electrical faults). Accessing system, electrical work, refrigerant charging, refrigerant recovery and decommissioning.</td>
<td>MC2</td>
</tr>
</tbody>
</table>
Performance outcome 1 - Install air conditioning systems

2.1 Sequence and prioritise tasks.

**What do learners need to learn?**

Interpret the customers' requirements and plan the installation to cause minimum disruption and liaise with other trades to avoid conflict. Plan execution of program of works, liaison with other trades, method statements and risk assessments.

**Skills**

| EC1 | EC4 | EC5 |

2.2 Identify **information requirements** for the task.

**Range:**

**Information requirements** - drawings, manufacturer’s specifications, regulatory documents, industry codes of practice, manufacturers’ instructions, installation specifications, permits to work, method statement, risk assessment.

**What do learners need to learn?**

Identify all the information needed from a range of sources to ensure compliance with local and national by-laws and legislation and any specific manufactures requirements.

**Skills**

| EC4 | EC5 |

2.3 Gather **information** required for the task.

**Range:**

**Information** - Manufacturer’s instructions, non-domestic building services compliance guide, Building Regulations, local by-laws.

**What do learners need to learn?**

Gather all necessary information from a range of sources to ensure compliance with local and national by-laws and legislation and any specific manufactures requirements.

**Skills**

| EC4 |
2.4 Produce written reports to stakeholders about work completed.

**Range:**

**Reports** - handover information, operation instructions, F-Gas records, maintenance instructions, job sheet/card, commissioning record.

<table>
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<tbody>
<tr>
<td>Produce written completion documentation for legal compliance (F-gas records) and customer information (operation instructions).</td>
<td>EC1 EC3</td>
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</table>

2.5 Measure and mark out installation requirements.

**Range:**

**Installation requirements** pipe routes, location of air handling units, condensing units, connection to services (electricity, gas, water, drainage, ventilation).

<table>
<thead>
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<tbody>
<tr>
<td>Locate and mark out the location of indoor and outdoor sections of the system together with pipe routes for refrigerants, water, drainage and electrical cabling and consideration of connection to services.</td>
<td>MC1</td>
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</table>

2.6 Connect components.

**Range:**

**Components** heating and cooling coils.

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</tr>
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</table>
2.7 Insert **components** into system.

**Range:**
**Components** - heat exchangers, condensing units, evaporators, condensate drains, valves, electrical cabling, drier, pressure switches, pumps, sight glass, vessels, thermostatic expansion valves, solenoid valves, vibration eliminators, Schrader valves, pressure transducers.

<table>
<thead>
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<tbody>
<tr>
<td>Safely connect the specified range of components into a system, with consideration given to temperature sensitive components and make any electrical connections as necessary.</td>
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</table>

2.8 Adjust **components**.

**Range:**
**Components** - belts, dampers, expansion valves, pressure switches, pressure regulation valves, head pressure controls, temperature controls.

<table>
<thead>
<tr>
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<tr>
<td>Adjust a range of components in accordance with manufacturer’s instructions.</td>
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</table>

2.9 Connect **control systems**.

**Range:**
**Control systems** - electronic controllers, head pressure controls, pressure/temperature transducers, building management systems, central control systems.

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<tr>
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<tbody>
<tr>
<td>Connect a range of control components including sensors and programmers to the refrigeration and control circuit, make safe electrical connections as needed.</td>
<td>DC1</td>
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</table>

2.10 Apply final settings.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
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</thead>
<tbody>
<tr>
<td>Calculate the correct additional charge for an air conditioning system in accordance with manufacturer’s instructions.</td>
<td>MC2</td>
</tr>
</tbody>
</table>
2.11 Confirm system is ready to commission.

**What do learners need to learn?**

Consider pre-commissioning checks, such as strength and tightness pressure/leak testing, electrical supply, electrical connections, temperature controllers, cabling before start-up of a system.
Performance outcome 3 - Commission air conditioning systems

3.1 Interpret a risk assessment.

**What do learners need to learn?**

Interpret risk assessments with consideration to responsibilities and persons at risk, applying controls, recording potential hazards and completion of documentation.

Skills

| EC4 | EC5 |

3.2 Interpret information provided.

**Range:**

**Information** - BS EN378, F-Gas regulations, contractual specifications, manufacturer’s instructions, including the bill of materials and site plans.

**What do learners need to learn?**

Interpret regulatory, contractual and manufacturer’s specifications and requirements in readiness to carryout system commissioning.

Skills

| EC4 | EC5 |

3.3 Interpret commissioning data including determining **design parameters** have been met.

**Range:**

**Design parameters** - superheat, subcooling, coil approach temperature, (delta T), air flow, air distribution, air on and off temperature, oil pressure, system running pressures, running current, relative humidity, primary and secondary refrigerant flow rates, temperature set-points.

**What do learners need to learn?**

Interpret recorded data to ensure the design conditions and parameters are met.

Skills

| MC6 | DC4 |
3.4 Explore **requirements** of the task.

**Range:**
**Requirements** - energy efficiency requirements, heat recovery, required temperature and humidity, sound levels, air flow rates.

**What do learners need to learn?**
Use open questioning and listening techniques to ensure that the client’s requirements and needs are met.

**Skills**
- EC2
- EC4
- EC5
- EC6

3.5 Visually inspect system installation.

**What do learners need to learn?**
Conduct a visual inspection of the complete system to ensure cleanliness, security of all fixings and mountings. Ensure all works are complete, safe and meet the specification before commencement of the commissioning activity as per contractual and manufacturer’s specification.

**Skills**

3.6 Establish a **steady state** operation.

**Range:**
**Steady state** - Running pressures, temperatures, running current, room temperature (dry and wet bulb).

**What do learners need to learn?**
Interpret the data readings recorded to ensure that the steady state conditions achieved meet the contractual requirements.

**Skills**
- MC6
- DC3

3.7 Collect **data** from control system.

**Range:**
**Data** - Primary and secondary refrigerant flow rates, temperatures, humidity and filtration/air quality levels.

**What do learners need to learn?**
Complete measurement of all required parameters such as temperatures, pressures, electrical currents and flow rates to ensure the system is running at maximum efficiency.

**Skills**
- MC5
- MC6
3.8 Record **data** from commissioning instrumentation.

**Range:**
**Data** - air quality, differential pressure, wet and dry temperature.

What do learners need to learn?
Use commissioning instruments to collect and record data such as temperatures, systems pressures, flow rates and running currents.

Skills
- MC5
- MC6
- EC3

3.9 Check **function** of system against design specification.

**Range:**
**Function** - air quality, filtration, differential pressure, wet and dry bulb temperature, energy efficiency.

What do learners need to learn?
Use the measured commissioning data to adjust the air conditioning system to achieve the required conditions and maximum energy efficiency.

Skills
- MC5

3.10 **Adjust** system to comfortable ambient conditions to ensure maximum performance and efficiency.

**Range:**
**Adjust** - Temperature set points, pressure controls, air flow rates, air distribution, energy efficiency.

What do learners need to learn?
Undertake appropriate testing and interpret data to adjust the system controls to achieve the environment conditions and maximise energy efficiency.

Skills
- MC6
Performance outcome 4 - Maintain air conditioning systems

4.1 Produce a **method statement**.

**Range:**
**Method statement** - Scope of works, manufacturer’s instructions, contractual requirements, risk assessment, preventative or reactive maintenance, permits to work.

**What do learners need to learn?**

Produce a method statement and risk assessment for either preventative or reactive maintenance through interpretation of system data, customer reports or contractual requirements.

**Skills**
EC1
EC2
EC4

4.2 Assess the suitability of **information** available.

**Range:**
**Information** - previous service records, F-Gas records, customer, senses, site logs.

**What do learners need to learn?**

Consider all of the information available with regard to its accuracy, sufficiency, currency and reliability before creating a maintenance plan.

**Skills**
EC4
EC5

4.3 Calculate **resource requirements** for servicing the systems.

**Range:**
**Resource requirements** - lubricants, filters, cleaning agents, spare parts, consumables.

**What do learners need to learn?**

Consider the maintenance plan and manufacturers instruction to compile a list of all materials needed to complete the maintenance task.

**Skills**
MC2
EC3

4.4 Complete **documentation**.

**Range:**
**Documentation** - maintenance plan, maintenance report, F-Gas records.

**What do learners need to learn?**

Complete all documentation in line with contractual and legislation requirements.

**Skills**
EC3
4.5 Visually inspect systems.

**What do learners need to learn?**

Carry out a visual inspection of the system first, with consideration given to health and safety and possible faults that may not be apparent to the client/customer.

Inspection to include checks for corrosion, refrigerant or water leaks, damage, loose screws or connectors.

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<th>Skills</th>
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</table>

4.6 Clean **systems**.

**Range:**

**Systems** - Indoor and outdoor coils, air filters, water filters, drain pans, drain lines, unit casings.

**What do learners need to learn?**

Carry out a wide range of cleaning activities with consideration given to health and safety and maintaining maximum energy efficiency.

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<th>Skills</th>
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</table>

4.7 Tighten loose **components**.

**Range:**

**Components** - screws, nuts, bolts, electrical connectors, wall/ceiling fixings.

**What do learners need to learn?**

Inspect, check and tighten all screws and connections, ensuring safe isolation procedure is carried out before checking any electrical connections.

<table>
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<th>Skills</th>
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</table>

4.8 Adjust **components**.

**Range:**

**Components** - dampers, belts, expansion valves, pressure switches, pressure regulation valves, head pressure controls, temperature controls.

**What do learners need to learn?**

Check and adjust all components in line with manufacturer’s instructions.

| Skills |
4.9 Lubricate bearings and other moving parts.

**What do learners need to learn?**

Identify and lubricate all components within the scope of works to include pulleys, heat recovery wheels, fan motors.

**Skills**

4.10 Check unit is running according to **optimum settings**.

**Range:**

- **Optimum settings** - manufacturer’s instructions and specifications, recorded data (temperatures, pressures, currents), client comments.

**What do learners need to learn?**

Use manufactures data and recorded data to ensure the system is running at optimum design conditions and maximum energy efficiency.

**Skills**

- MC6
- EC5

4.11 Review system against minimal risks from **potential health hazards**.

**Range:**

- **Potential health hazards** - sick building syndrome (SBS), poor air distribution, blocked or missing air filters, static water (Legionella).

**What do learners need to learn?**

Inspect the system with regard to other potential hazards such as Legionella and Sick Building Syndrome and advise or take action as needed.

**Skills**

- MC2
- MC6
- EC5

4.12 Assess **system risks** for long term performance.

**Range:**

- **System risks** - components reaching end of life, wear and tear, previous service reports.

**What do learners need to learn?**

Consider system information to make an assessment as to the potential life of system components and make recommendation or take action as needed.

**Skills**

- MC2
- MC6
- EC5
4.13 **Report** on maintenance activities.

**Range:**
**Report** - job sheet/cards, F-Gas records, maintenance reports, verbal report to client or supervisor.

**What do learners need to learn?**

Produce verbal and written reports based on the recorded data and the results of the inspection and works carried out.

**Skills**

| EC1 | EC2 | EC3 | EC4 | EC6 | DC2 | DC1 |

4.14 Investigate **system operation parameters** to identify faults.

**Range:**
**System operation parameters** - commissioning data, manufacturers data, system data current and historical, design parameters, refrigerant side, air flow, secondary refrigerant flow, electrical control function, site logs, previous service records.

**What do learners need to learn?**

Using a range of information and system data including the senses (sight, touch, hearing, smell) conduct fault analysis to investigate actual or potential faults and construct a plan to put the system back into full operation.

**Skills**

| MC2 | MC6 | EC4 | EC5 | DC4 |

4.15 Rectify system.

**What do learners need to learn?**

Use the results of a fault-finding analysis to carry out a system repair or component replacement to put the system back into full operation. This could include the following faults Refrigerant leaks, system components, electrical faults, air flow.

**Skills**

| MC2 | MC6 |
Links to Core Skills

As part of delivery of the skills and knowledge within this specialism reference should be made to criteria that support the development of the four core skills – communication, working collaboratively, problem solving and research. Some examples of criteria that may be linked to supporting these core skills include:

- Communication e.g. providing information and advice to customers and/or wider stakeholders on the potential risks of a change to an industrial system, or making a presentation to a stakeholder on the implications of change
  
  **Example criteria**
  
  o 4.13 will support a learner’s personal development in how to communicate with others, by producing verbal and written reports on results of tasks carried out.

- Applying a logical approach to solving problems, identifying issues and proposing solutions e.g. through setting criteria for successful implementation of a system, using cost/benefit analysis of the introduction of new procedures or equipment
  
  **Example criteria**
  
  o 2.12 will support a learner’s personal development in how to apply a logical approach to solving problems by considering all pre-commissioning checks before start-up of system.

- Primary research e.g. obtaining measurements related to a design and/or customer requirements.
  
  **Example criteria**
  
  o 3.3 will support a learner’s personal development in how to research by interpreting commissioning data including determining design parameters have been met.

Aspects of the air conditioning specialism can also be closely linked to the refrigeration specialism. For candidates taking both the air conditioning and refrigeration specialisms, opportunities for efficiencies in delivery include:

- Tools, equipment and materials
- Fault finding techniques
- Interpreting and producing written information
- Calculations and measurements of data

Guidance for delivery

- Opportunities for efficiencies in delivery

There are opportunities to consolidate learning where elements of content are common across performance outcomes, for example:

  o Jointing
  o Charging
  o Recovery

Where content is common across installation, commissioning and maintenance activities, it is recommend that these are delivered once and contextualised where needed.

- Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery
• Formative assessment – oral Q&A, SmartScreen worksheets (samples available) observation of measuring activities
  o Practical - Use of pre-set formative assessments carry out tasks and record on standardised form. Use of a variety of measuring instruments
  o Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT
• Ways of ensuring content is delivered in line with current, up to date industry practice
  o Delivery for this specialism will take place in a dedicated air conditioning classroom/workshop
  o A realistic representation of air conditioning systems and components should be installed in the classroom/workshop
  o Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
  o The provision must represent the type of equipment currently available in the UK air conditioning industry
  o New and emerging air conditioning technology should be included in the delivery

Suggested learning resources

Books
• Refrigeration & Air Conditioning
• The Motivate Series. Refrigeration & Air Conditioning Technology
• Modern Refrigeration & Air Conditioning 19th Edition
• Air Conditioning Practical Introduction
• Refrigeration and Air Conditioning (5th edition)

Websites
• www.ior.org.uk
• BSEN378:2016 standard www.shop.bsigroup.com
• www.acrib.org.uk
• www.summitskills.org.uk
• F Gas www.gov.uk
• F-Gas www.refcom.org.uk
What is this specialism about?
The purpose of this specialism is for learners to know and undertake fundamental electrical and electronic engineering processes and procedures. Learners will have the opportunity to plan, perform and evaluate their work whilst using a range of materials, methods and techniques.

Learners will develop their knowledge, understanding and skills in:

- Health and safety practices associated with electrical and electronic systems
- Tools, materials and equipment used to complete tasks in electrical and electronic systems
- Systems and products used in electrical and electronic systems
- Installing, commissioning, and decommissioning electrical and electronic equipment systems
- Maintaining electrical and electronic equipment systems

Learners may be introduced to this specialism by asking themselves questions such as:

- What different types of monitoring equipment are used in electrical and electronic systems?
- Why are there different types of electrical supply?
- How are wires and circuit components connected safety?

Underpinning knowledge outcomes
On completion of this specialism, learners will understand:
1. Electrical and electronic equipment engineering knowledge criteria

Performance outcomes
On completion of this specialism, learners will be able to:
2. Install electrical and electronic equipment systems
3. Commission electrical and electronic equipment systems
4. Maintain electrical and electronic equipment systems
Completion of this specialism will give learners the opportunity to develop their Maths, English and Digital Skills. Details are presented at the end of the specification.
Specialism content

Common knowledge criteria

Health and safety
1.1 Risk assessments and safe working procedures for activities involving electrical and electronic equipment.

What do learners need to learn?
Risk assessment requirements and considerations before any work activities are undertaken - use of method statements, necessity for safe isolation of systems being worked on.

Skills
EC5

Tools, equipment and materials
1.2 Tools, equipment and materials used for installation and their purpose.

Range:
Hand tools - rules, levels, cable cutters, screwdrivers, wire strippers, knives, wrenches, hammers, saws, data cabling crimps, insulation displacement tools

Power tools - hammer drills, electric screwdrivers

Equipment - test equipment, ICT equipment

What do learners need to learn?
Selection of correct hand/power tools, equipment and materials that is required to complete work activities associated with Electrical and Electronic equipment engineering within BSE.

Skills

1.3 Tests required, including portable appliance testing (PAT) to ensure products and equipment meet national and international safety standards.

What do learners need to learn?
Ensure all products and equipment have been tested correctly in accordance with Portable Appliance testing procedures and in line with the IET Code of Practice for the in-service inspection and testing of electrical equipment (IET CoPIITEE).
1.4 Operation and handling requirements for power tools and equipment.

Range:
Requirements - asset register, regular user checks, PAT, IET Code of Practice IITEE.

What do learners need to learn?
Safe use of tools in accordance with manufacturer's instructions and industry standards.

Systems and products
1.5 Requirements of systems in meeting product and building operations.

Range:
Systems - lighting, power, heating, protection.

What do learners need to learn?
Requirements of the systems listed in the range, along with their interfacing equipment. Selection of equipment used to meet energy efficiency requirements/considerations within Building Regulations and BS 7671.

1.6 Electrical and electronic equipment, including related software.

Range:
Electrical and electronic equipment - electrical power and lighting controls, heating system controls, monitoring systems (BMS/instrumentation/software), protection systems.

What do learners need to learn?
Characteristics, types and purpose of the different types of systems/equipment used in Building Management and control systems.

Suitability of equipment for installation location and external influences. How components operate within a system and integrate to enable the product and system to operate effectively including different types of connectivity and wireless systems available including the Internet of Things (IoT).

Other systems available including Wi-Fi, Bluetooth etc. The operation of the building systems and their individual components, how these components are connected to each other, if they are hard wired, connected wirelessly through Bluetooth, or through a central hub. Concepts and development with the IoT.

Skills
DC1
DC5
DC6
1.7 Types of monitoring systems.

Range:
Monitoring systems - BMS, PLC, fire alarm, emergency lighting, security (intruder/access), heating and ventilation.

What do learners need to learn?  
Operation of different types of monitoring systems, how the data is connected between them, and the use of networks within buildings. The types of data produced by systems and how the data is produced and extracted considering different types of wireless systems available.

Skills

1.8 Types of AV equipment.

Range:
AV equipment - optical media, display screens, infra-red transmitters, sound systems, PA and voice control systems.

What do learners need to learn?  
Operation and connectivity of the different types of AV equipment within the range specified.

Skills
Specific knowledge criteria for performance outcomes

**System installation (PO2)**

1.9 **Cable and wiring system component** installation and their supports.

**Range:**

*Cable and wiring system components* - single and multicore thermoplastic cable, SWA multicore armored cable, MICC, FP200- Fire resistant cable, data cable Cat5/6, enclosures (cable tray, cable conduit (steel and PVC), cable trunking, ladder racking, cable basket).

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<thead>
<tr>
<th>What do learners need to learn?</th>
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<tr>
<td>Methods of installing cables to a range of wiring and containment systems into a new or existing building including requirements for the installation of wiring in buildings as BS 7671.</td>
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</table>

1.10 **Methods** of terminating cables into accessories.

**Range:**

*Methods* - SWA glands, rigid cable glands, flexible cable glands, grips, clamps.

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<thead>
<tr>
<th>What do learners need to learn?</th>
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<tr>
<td>Different methods for terminating cables into enclosures and accessories, to meet manufacturer’s instructions and industry practices for the cables as ranged in 1.9.</td>
<td></td>
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</tbody>
</table>

1.11 Identification of **electrical supply** and **earthing arrangements**.

**Range:**

*Electrical supply* - single phase, polyphase, DC, renewables.

*Earthing arrangements* - TT, TN-S, TN-C-S.

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<thead>
<tr>
<th>What do learners need to learn?</th>
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<tr>
<td>Identification of different earthing systems and supplies to enable suitable selection of interfacing equipment.</td>
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</table>
1.12 Electrical circuit types.

Range:
Circuit types - power - radial and ring final circuits, lighting – switching and ELV, control.

What do learners need to learn?
Identification of different types of electrical circuits in line with current Building Regulations and BS 7671.

Skills

1.13 Methods used to terminate and connect conductors.

Range:
Methods - screwed, crimped, compression connections, soldered, insulation displacement

What do learners need to learn?
Methods used to terminate and connect conductors using a variety of methods recognised within the industry.

Skills

1.14 Broadband and Wi-Fi requirements and how to assess suitability for interfacing equipment.

Range:
Interfacing equipment - routers, hubs, data receivers, smart interfaces

What do learners need to learn?
Communication systems and interfacing equipment used by the installed equipment to monitor/control. Identify the software systems in use.

Skills DC1

1.15 Existing systems and implications for new installations.

What do learners need to learn?
Implications of installing new equipment into existing installations, and the problems associated with older installation cable types and the installed equipment. With consideration of implications including:

- Cable types and sizes.
- Electrical accessories and equipment.
- Requirements for segregation.
1.16 Decommissioning existing systems in preparation for new installations.

**What do learners need to learn?**

Safe isolation procedures and the risks associated with older installations, i.e. building materials (asbestos). New installations including:

- Processes to make existing products and systems safe to decommission before installation of new products e.g. isolate electrical and plumbing supplies
- How to identify potential issues before decommissioning a system.

**System commissioning knowledge (PO3)**

1.17 Inspections of electrical and electronic equipment before putting into service.

**What do learners need to learn?**

Processes for inspecting electrical and electronic equipment, associated wiring and documentation required during the process, i.e. manufacturer’s instructions, BS 7671, for example when checking correct electrical connections.

1.18 Testing of electrical and electronic equipment.

**What do learners need to learn?**

Tests required and where applicable the sequence in which they are performed with reference to BS 7671 and manufacturer’s instructions.

1.19 Adjusting equipment to meet installation standards to ensure correct function.

**What do learners need to learn?**

Manufacturer’s information followed for the setting up and commissioning of electrical and electronic equipment including functional testing.
1.20 Handover of equipment to client.

**What do learners need to learn?**

Handover procedure to client including records, demonstration, O&M manuals, maintenance requirements and certification.

**Skills**

| EC1 | EC2 | EC3 | EC6 |

**System maintenance knowledge (PO4)**

1.21 Fault finding **techniques**.

**Range:**

**Techniques** - safe isolation, system updates (automatic and manual), manufacturers maintenance schedules, collection of data, analysis of data, plan fault finding and tests, carry out fault finding, repair, test, use of questioning.

**What do learners need to learn?**

Logical and systematic process steps in the determination and repair of system faults. Suitable precautionary measures such as safe isolation and anti-static measures.

**Skills**

| MC2 |

1.22 Technology for maintaining, fault finding and diagnostic work as well as software / firmware updates.

**What do learners need to learn?**

Current fault finding instruments, information and techniques used to diagnose and rectify system faults.

**Skills**

| MC2 |
1.23 Patterns of system failure and requirements for regular maintenance, repair or replacement.

**What do learners need to learn?**

Equipment required, with reference to manufacturers data and likely components that may fail.

Ensuring that a range of components are held as spares, for each of the systems, including the reasons for doing so – i.e. potential reduction of downtime.

Checking manufacturer’s software and firmware support including items no longer supported by system updates.

Advising stakeholders on suitable methods for maintaining or updating systems and components.

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<td>MC2</td>
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</table>
Performance outcome 2 - Install electrical and electronic equipment systems

2.1 Assess risk associated with tasks.

**What do learners need to learn?**

Assessment of risk may relate to the production or review of a risk assessment for installation activities, with consideration of specialist equipment required.

Risks will vary depending on system being installed but may include for example whether any specialist equipment is needed etc.

Consideration should be made with reference to recording of risk assessment findings in line with regulations as well as responsibilities of employee’s vs employers.

**Skills**

2.2 Identify and review information required to complete tasks, ensuring accuracy and validity, including suitability of equipment being installed.

**Range:**

**Information** - manufacturer’s instructions, Building Regulations, drawings, BS - EN standards, data sheets.

**What do learners need to learn?**

Identifying information in the specification and drawings for the installation and checking that this information against the manufacturer’s installation instructions to ensure that all the available information is present for the installation.

Ensuring that the information obtained is accurate, that it is valid, and that the equipment is suitable for the installation.

**Skills**

EC4 EC5

2.3 Select and inspect tools, equipment, resources and materials required to complete task.

**What do learners need to learn?**

Identifying information in the specification and drawings for the installation and checking that this information against the manufacturer’s installation instructions to ensure that all the available information is present for the installation.

Ensuring that the information obtained is accurate, that it is valid, and that the equipment is suitable for the installation.

**Skills**
2.4 Mark out the position of electrical and electronic equipment.

**What do learners need to learn?**

Using the correct measuring and levelling equipment, along with the installation drawings, mark out the position of the equipment.

**Skills**

MC1

2.5 Analyse situations to identify potential causes for delays and errors.

**What do learners need to learn?**

Identifying any possible causes for delay in the installation e.g. installation site not ready, equipment not delivered, lack of experienced qualified installation engineers and ensure that the client is informed of any likely delays.

**Skills**

MC1

MC2

2.6 Think creatively to adapt designs as appropriate.

**What do learners need to learn?**

Identifying and considering changes to the installation method, taking into account any change in the installation site or changes to equipment being installed for example where site conditions are different to information provided.

**Skills**

2.7 Use tools and equipment to carry out tasks.

**What do learners need to learn?**

Selecting and using the appropriate hand and power tools to fit cables to brackets, supports, containment systems and wiring systems.

The brackets and supports need to be fitted the correct distances in accordance with the installation specification, industry practices and relevant standards.
2.8 Handle materials.

**What do learners need to learn?**

Handling containment materials and cabling must be carried out safely and in accordance with the Manual Handling Operations Regulations. Ensuring that lifting aids are available and have been checked for operation and damage, that any lifting tackle available is suitable and serviceable. Ensure all PPE relevant to the handling task is available and worn (gloves and boots).

**Skills**

2.9 Make systems safe to work on including safe isolation and discharging stored charge as well as isolation of water services.

**What do learners need to learn?**

Following safe isolation procedure of the electrical supply, that any stored charge has been discharged, also ensure that any other services, such as water are also isolated where appropriate.

**Skills**

2.10 Connect electrical and electronic equipment to the installed systems.

**What do learners need to learn?**

Connecting the electronic and electrical equipment to the installed systems using safe industry practices and in accordance to manufacturer’s installation specifications.

**Skills**

2.11 Install cable and cable containment systems.

**What do learners need to learn?**

Installing cabling to previously fitted containment to industry standards, taking care not to damage the cable.

**Skills**
2.12 Terminate cables and connect conductors.

**What do learners need to learn?**

Terminating the cables using the appropriate glands and ensure that they are tight and secure to industry standards and manufacturer’s instructions.

Connecting conductors, for example to terminate into relevant terminals, using appropriate tools. Connections to be made using screwed, compression, crimped, insulation displacement or soldered connections.

**Skills**

2.13 Connect additional components to existing building services engineering systems.

**What do learners need to learn?**

Making connections to any associated existing building services engineering systems in the range, using current industry techniques and manufacturers information.

**Skills**

2.14 Remove electrical, electronic and mechanical equipment.

**What do learners need to learn?**

Removing and correctly disposing of any redundant materials and systems, ensuring that any recycling is carried out.

Ensuring that any hazardous waste has been handled and disposed of by the correct methods and procedures.

**Skills**
Performance outcome 3 - Commission electrical and electronic equipment systems

3.1 Inspect electrical and electronic equipment.

What do learners need to learn?
Completing inspections as per relevant electrical inspection schedules used in accordance with BS 7671 and IET Guidance Note 3. Consideration should also be given to O&M manuals and manufacturers data.

Skills

3.2 Test electrical and electronic equipment systems.

What do learners need to learn?
Testing carried out on electrical system in accordance with the BS 7671 and IET Guidance Note 3 where applicable. Identifying the appropriate instrument for each test to be carried out in terms of:
- The instrument is fit for purpose
- Identifying the correct scale or setting
- Specifying the requirements for the safe use of instruments to be used for testing and commissioning

Consideration to the testing of equipment in accordance with manufacturer's information.

Skills

3.3 Complete required documents for the task.

What do learners need to learn?
Explaining the purpose of certification and associated documentation and information that must be contained on completion documentation.

Certification process for a completed system, the requirements for the recording and retention of completed initial verification documentation in accordance with the BS 7671 where applicable.

Skills
EC1
EC3
EC4
EC5
3.4 Analyse and interpret test information and data.

**What do learners need to learn?**

Analysing and interpreting information from various digital and non-digital sources.

**Skills**

| MC6 | DC1 | DC4 | DC5 |

3.5 Identify inadequate installations.

**What do learners need to learn?**

Comparing results against the design criteria, manufacturers data and BS 7671, where applicable, and checking suitability. Where inadequate results are confirmed, client and manufacturers would need to be informed.

**Skills**

| EC1 | EC6 | MC2 | MC6 | DC4 |

3.6 Setup connection including network and router.

**What do learners need to learn?**

Setting up of routers and hubs to enable Wi-Fi, follow system instructions to network equipment, either hard wired or wireless.

**Skills**

3.7 Review performance in relation to customer network.

**What do learners need to learn?**

Using apps to check the speed of the internet using the customers network. Desired/optimum speeds should be detailed in any manufacturers data.

**Skills**

| EC5 | DC4 | DC5 | DC6 |
3.8 Demonstrate product and present information to customer.

What do learners need to learn?

Operating the system and completing a full report on the system. Using the manufacturers information and instructions to demonstrate that installed equipment is functioning correctly and within any limits/tolerances.

Detail the energy saving practices that should be followed, like suggesting the promotion of switching equipment off instead of leaving on standby.

Using energy efficient lighting such as LED’s. Ensure the registration of the equipment is carried out with the manufacture where equipment is under warranty.
**Performance outcome 4 - Maintain electrical and electronic equipment systems**

4.1 Communicate health and safety risks to stakeholders orally.

**What do learners need to learn?**

Communicating with stakeholders in line with system maintenance for example explaining unsafe situations and the risks associated with them.

Communications may relate to the production of a risk assessment for maintenance activities explaining relevant content of the risk assessment to stakeholders.

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4.2 Sequence activities required to complete tasks including planning to isolate electrical supplies and informing relevant people where required.

**What do learners need to learn?**

Following correct sequence of activities to complete maintenance tasks:

- Selecting tools/equipment
- Obtaining method statement/work order
- Carrying out safe and secure isolation (including getting permission to isolate)
- Carrying out maintenance activities
- Removing isolation
- Functional testing

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4.3 Allocate time and resources to complete tasks including materials required.

**What do learners need to learn?**

Reviewing sequence as detailed in 4.2 depth with application of appropriate timings for each stage. Liaison with stakeholders to agree timings to minimise disruption and enhance safety.

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4.4 Collect system data from ICT applications and other sources.

Range:
Sources - questioning of client/end user, O&M manuals, manufacture’s data sheets.

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<tr>
<td>ICT including use of computers, digital transmission over IP, email, mobile communication technology etc for the collection of data and completion of work sheets/maintenance sheets.</td>
<td>DC1 DC2 DC3 DC5</td>
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4.5 Record system data.

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<th>What do learners need to learn?</th>
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<tbody>
<tr>
<td>System data may include work records or equipment maintenance sheets etc. Familiarity with records of work, including preventative maintenance and reactive maintenance requirements. Inspection and test schedules maybe company or system specific, so awareness required of documentation to be completed for maintenance activities.</td>
<td>EC1 EC3 EC4</td>
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4.6 Test equipment to ensure it is safe to work on.

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<td>Carrying out checks to ensure safe isolation has been carried out correctly and that any stored charge within the equipment has been discharged.</td>
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4.7 Inspect, test and analyse information to identify potential faults.

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<th>What do learners need to learn?</th>
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<tr>
<td>Inspection for potential faults on system components through visual inspection of system, operational checks, feedback from system users and performance, testing to gather information to be used as part of analysis of situation, checking software for corruption, viruses, EoL (End of Life) etc.</td>
<td>EC4 EC5 MC2 MC6 DC4 DC5</td>
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</table>

Collating all available information and analysing regarding any possible or potential faults. Reference may also be made to manufacturer’s instructions or specifications (e.g. fault finding flow chart or detailed procedure). Checking system performance criteria for correct settings, readings or maximum/minimum permitted standards. Analyses of conditions that affect suitability of systems such as alterations to building, structure or equipment.
4.8 Think creatively to propose solutions for system faults.

**What do learners need to learn?**

Using analysis, develop strategic, economic and practical methods for rectifying identified possible or potential faults.

System faults and issues may include deteriorating or outdated equipment over time and having contingency plans in place for equipment that is no longer manufactured, or supported etc.

Site inventory is required with all equipment details assigned including age. Storage of spare parts is required for equipment and parts of systems that may fail due to a number of reasons.

Contingency budget planning needs to be reviewed regularly with consideration given to performance levels of existing equipment and plant.

**Skills**

MC2
MC7
MC10

4.9 Communicate written technical advice and guidance to technical and non-technical stakeholders.

**What do learners need to learn?**

Communicate with stakeholders and obtain necessary permissions to rectify faults, prolong potential faults or improve systems for changing conditions.

Learners must be able to overcome potential barriers to successful communication with specific reference to language and methods used for both technical and non-technical stakeholders.

**Skills**

EC1
EC3
EC6
DC3
DC5

4.10 Replace components or update software.

**What do learners need to learn?**

Replacing components or updating software within a system as necessary to meet industry and task specific requirements.

Consideration should be made to safe/appropriate disposal of replaced components and ensuring all work has been recorded or records of work updated, including O&M manuals.

**Skills**
Electrical and electronic equipment

Links to Maths, English and Digital Skills

Maths
- Calculations and estimations of time required, and resources needed to complete maintenance tasks (4.3)

English
- Identifying and interpreting data required to complete tasks for example from manufacturer documentation, which may be presented in different ways – tables, charts, text etc (2.2)
- Presenting information to customers/clients clearly and persuasively with appropriate language, overcoming potential barriers (3.8)
- Using different types of questioning techniques/use of technical language, communication to confirm understanding (4.1)

Digital
- Use of digital equipment for the testing of electrical systems (3.2)
- Use of software packages when interpreting and analysing electrical system information and reviewing project management literature and plans (3.4)
- Collection of data from digital sources as part of integrated monitoring systems (4.4)
- Using system software to interrogate and analyse data as part of system maintenance (4.7)

Core content
All aspects of the common core and BSE specific core content can be related and contextualised on delivery in relation to this specialism. However, the following are key areas of the content that may be of particular relevance when delivering the knowledge and practical content for this specialism and may provide efficiencies for teaching core knowledge in context;

Common core content
- Construction science principles – electricity, heat
- Construction sustainability principles - Energy production and energy use
- Building technology principles - Internet of things
- Construction information and data principles - Key elements of data

BSE specific core content
- Digital technology in construction - Internet of things, digital engineering techniques, opportunities for the use of technology used in other industries and contexts and adapting for use in construction and the built environment
- Health and safety - BSE Regulations, safe working practices for the safe isolation of systems
- Building Services Engineering (BSE) systems - Electrotechnical principles of components, types of control systems, types of monitoring systems, types of electrical supply, types of earthing arrangements, cable types and sizes, accessories and equipment used in older electrical installations
- Information and data - Drawings, circuit diagrams and schematics, data storage, security and protection, programming and set up of digital systems using IT resources
Links to Core Skills

As part of delivery of the skills and knowledge within this specialism reference should be made to criteria that support the development of the four core skills – communication, working collaboratively, problem solving and research. Some examples of criteria that may be linked to supporting these core skills include:

- **Communication** e.g. providing information and advice to customers and / or wider stakeholders on the potential risks of a change to an industrial system or making a presentation to a stakeholder on the implications of change.
  
  **Example criteria**
  
  - 3.8 Demonstrate product and present information to customer.
  - 4.1 Communicate orally health and safety risks to stakeholders.
  - 4.9 Communicate written technical advice and guidance to technical and non-technical stakeholders.

- **Working collaboratively** with other team members and stakeholders e.g. to develop content to bid for a construction project.
  
  **Example criteria**
  
  - 4.1 Communicate orally health and safety risks to stakeholders.
  - 4.9 Communicate written technical advice and guidance to technical and non-technical stakeholders.

- **Applying a logical approach to solving problems**, identifying issues and proposing solutions e.g. through setting criteria for successful implementation of a system, using cost / benefit analysis of the introduction of new procedures or equipment.
  
  **Example criteria**
  
  - 2.5 Analyse situations to identify potential causes for delays and errors.
  - 2.6 Think creatively to adapt designs as appropriate.
  - 3.4 Analyse and interpret test information and data.
  - 4.2 Sequence activities required to complete tasks including planning to isolate electrical supplies and informing relevant people where required.

- **Conducting primary research** e.g. obtaining measurements related to a design or customer requirements.
  
  **Example criteria**
  
  - 2.2 Identify and review information required to complete tasks, ensuring accuracy and validity, including suitability of equipment being installed.
  - 2.4 Mark out the position of electrical and electronic equipment.
  - 4.4 Collect system data from ICT applications and other sources.

Guidance for delivery

- Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery
- Formative assessment – oral Q&A, SmartScreen worksheets (samples available), observation of measuring activities
  
  - Practical - Use of pre-set formative assessments to carry out tasks and record on standardised form
Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT

- Ways of ensuring content is delivered in line with current, up to date industry practice
  - Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
  - Teaching coverage must represent the type of equipment currently available and accepted for use in the UK industry
  - Current and emerging electrical installation and testing technologies should be included in the delivery where possible

- Reinforcement of learning – revisiting learning, group discussions, peer support system

Suggested learning resources

Books
- The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)
  Author: Peter Tanner
  Publisher: Hodder Education (28 Sept. 2018)
- The City & Guilds Textbook: Book 2 Electrical Installations for the Level 3 Apprenticeship (5357), Level 3 Advanced Technical Diploma (8202) & Level 3 Diploma (2365)
  Author: Peter Tanner
  Publisher: Hodder Education (25 Jan. 2019)
- Requirements for Electrical Installations, IET Wiring Regulations, Eighteenth Edition, BS 7671:2018 (Electrical Wiring Regulations)
  Author: The Institution of Engineering and Technology
  Publisher: Institution of Engineering and Technology; 18th Edition (2 July 2018)

Websites
- Institute for apprenticeships and technical education https://www.instituteforapprenticeships.org/
- National Careers Service https://nationalcareers.service.gov.uk/job-profiles/electrician
- Electrical Contractors’ Association (ECA) https://www.eca.co.uk/
- Institute of Engineering and Technology (IET) https://electrical.theiet.org/bs-7671/
- Health and Safety Executive https://www.hse.gov.uk/electricity/
- Safety Electrical First- https://www.electricalsafetyfirst.org.uk/
- Electrical Times- https://www.electricaltimes.co.uk/
- Sparks magazine (for trainees)- https://www.sparks-magazine.co.uk/
- Electrical Trade Magazine- https://www.electricaltrademagazine.co.uk/
What is this specialism about?

The purpose of this specialism is for learners to know and undertake fundamental electrotechnical systems engineering processes and procedures. Learners will have the opportunity to plan, perform and evaluate their work whilst using a range of materials, methods and techniques.

Learners will develop their knowledge, understanding and skills in:

- Health and safety practices associated with carrying out electrotechnical systems engineering
- Installation methods and termination connections
- Systems and products used in electrotechnical engineering
- Analysing and using information to and from electrotechnical systems
- Removal processes as part of system decommissioning

Learners may be introduced to this specialism by asking themselves questions such as:

- Who are the key stakeholders who may be involved with electrotechnical system installation and maintenance?
- How are electrotechnical systems checked and tested?
- When are different circuit types used in electrotechnical systems?

Underpinning knowledge outcomes

On completion of this specialism, learners will understand:

1. Electrotechnical engineering knowledge criteria

Performance outcomes

On completion of this specialism, learners will be able to:

2. Install electrotechnical systems
3. Commission electrotechnical systems
4. Maintain electrotechnical systems
5. Decommission electrotechnical systems
Completion of this specialism will give learners the opportunity to develop their Maths, English and Digital Skills. Details are presented at the end of the specification.
Specialism content

Common knowledge criteria

**Tools, equipment and materials**

1.1 **Tools** and **equipment** used for installation.

**Range:**

- **Hand tools** - rules, levels, gauges, plumb lines, cable cutters, screwdrivers, wire strippers, knives, files, wrenches, hammers, saws, data cabling crimps, insulation displacement tools, reamers.

- **Power tools** - hammer drills, pillar drills, electric screwdrivers.

- **Equipment** - testing/commissioning equipment, conduit benders, tray benders, bending springs, MI kit, stocks and dies.

**What do learners need to learn?**

Tools required related to the requirements of the job specification – identification of the range of both general and specific tools required. Selecting the correct hand and power tools required to complete work activities associated with electrotechnical systems, taking into consideration the safe use of equipment and suitability of tools and equipment matched to specific task.

**Skills**

1.2 Operation and handling requirements.

**What do learners need to learn?**

Techniques for safe use of hand and power tools, referring to specific guidance for tools required to complete and undertake tasks on specific activities. Safety checks necessary before use and regular checks necessary to avoid damage, deterioration and hazards.
Electrical installations
1.3 Principles of electrical circuits and loads

Range:
Circuits – Ring-final, Radial, lighting, series, parallel, AC, DC, magnetic effect, temperature effect, voltage drop.

Loads – AC, DC, resistive, inductive, capacitive, power factor, true power, apparent power

What do learners need to learn? | Skills
---|---
How different circuit arrangements affect voltage and current behavior. Control of loads by circuit arrangement and the reasons why particular circuit arrangements are selected.

Direct Current principles for series and parallel circuits. How temperature affects circuits as well as temperature induced by circuit conditions.

Factors that affect voltage drop and the effects of voltage drop in terms of load behavior and energy losses. How magnetism is induced and the effects of magnetism.

How different types of load affect current and voltage including resistive, inductive, and capacitive loads. How power factor is induced and how it changes circuit properties such as current, voltage and power.

Methods used to reduce power factor.

1.4 Assessment of general characteristics outlined in national standards

What do learners need to learn? | Skills
---|---
Assessing general characteristics of installations such as supply types, earthing arrangements such as TT, TN-S and TN-C-S. Determining maximum demands with application of diversity.

How external influences affect installation design, selection and erection. Taking maintainability into account when designing and certificating installation work.
1.5 Application of the fundamental principles of national standards.

**What do learners need to learn?**

Refer to the National Standards and the requirements of the Electricity at Work Regulations, Building Regulations, BS 7671 for the design, installation, inspection and testing of electrical systems and equipment.

Interpret and implement Fundamental Principles of BS 7671 including how they are detailed in Parts 4-6 of the standard.

Use of information in Appendices of BS 7671 and Guidance Notes to formulate installation design and protection giving consideration to the fundamental principles.

**Skills**

1.6 Special installations and locations specified in national standards.

**What do learners need to learn?**

Refer to Part 7 of the latest edition of the Requirements for Electrical Installation (BS 7671: IET wiring regulations) and IET Guidance notes 1-8 for information and support for electrotechnical activities within special locations as specified in the National Standards.

This includes identifying installations where specialist activities may be beyond the competency of non-specialist operatives.

**Skills**

1.7 Design concepts of installations specified in national standards.

**What do learners need to learn?**

Refer to the latest edition of the Requirements for Electrical Installation (BS 7671 IET wiring regulations), on-site guides and IET Guidance notes 1-8 for in depth information and support for protection for safety within electrical installations as specified in the National Standards.

Interpreting requirements and relating these to different circuit types and accessories that form typical electrical systems.

Selecting the correct protection methods and devices for typical systems including those required for protection, isolation control and switching.

**Skills**
1.8 Methods of selecting and installing wiring systems.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>How to ensure that electrical wiring systems are selected and installed in accordance with current legislation and industry practices, are fit for purpose and safe to be put into service.</td>
<td></td>
</tr>
<tr>
<td>Wiring systems may include armoured, insulated and sheathed cable types etc. How different wiring is arranged to form common low and extra-low voltage circuits such as radial power, lighting, ring-final and auxiliary.</td>
<td></td>
</tr>
</tbody>
</table>

1.9 Methods of selecting and erecting electrical installation components.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>With consultation of IET guidance documents in the installation of all electrical circuits and components, making sure that the installation meets the current legislation and industry practices.</td>
<td></td>
</tr>
<tr>
<td>Factors that affect suitable circuits and components including their protection and longevity.</td>
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</tbody>
</table>

1.10 Types of lighting and luminaire

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of different lighting, lamp types and luminaires used for different effects including efficacy, energy efficiency, lumens, regulatory lux levels and colour rendering.</td>
<td></td>
</tr>
<tr>
<td>How height and spacing of luminaires affect illumination values.</td>
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</tr>
</tbody>
</table>
Specific knowledge criteria for performance outcomes

System installation (PO2)

1.11 Methods of installing **cable installation and wiring system supports**.

**Range:**

**Cable installation and wiring system supports** - single and multicore thermoplastic cable, SWA multicore armoured cable, MICC, FP200- Fire resistant cable, flexible cable, data cable Cat5/6, cable tray, cable conduit (steel and PVC), cable trunking, ladder racking, cable basket, cable cleats, clips, cable hangers.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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</thead>
<tbody>
<tr>
<td>How to install cables and containment in line with current legislation and industry practices.</td>
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</tr>
<tr>
<td>Considerations when installing cables such as Building Regulations, manufacturer’s instructions, IET Guidance and British Standards.</td>
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</tbody>
</table>

1.12 Methods of **terminating** cables.

**Range:**

**Terminating** - cable glands, grips, clamps

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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</thead>
<tbody>
<tr>
<td>Termination and securing of cable terminations detailed in the range in line with specification requirements and current industry standards/working methods. When securing terminations consideration should be taken of Building Regulations, manufactures instructions and British Standards. Appropriate glands must be used to ensure security of cable types and checks should be made to ensure termination glands are suitable for external influences and secure.</td>
<td></td>
</tr>
</tbody>
</table>
1.13 Methods of **terminating and connecting** conductors.

**Range:**
**Terminating and connecting** - screwed, crimped, compression, soldered, maintained, non-maintained, insulation displacement.

**What do learners need to learn?**
Termination and securing of connections of conductors detailed in the range in line with specification requirements and current industry standards/working methods. When securing terminations/connections consideration should be taken of Building Regulations, manufactures instructions and British Standards. Appropriate connections/terminations must be used to ensure security of connection/termination types and checks should be made to ensure termination/connections are suitable for external influences and secure. Appropriate methods should be selected depending on the type of maintenance expected including access.

**System commissioning (PO3)**

1.14 Inspections for initial verification of electrotechnical systems.

**What do learners need to learn?**
Standard procedures and processes for how to undertake inspections including the items to be inspected when carrying out initial verification in accordance with BS 7671 and IET Guidance Note 3. Consideration should also be given to providing the required information including O & M manuals.

1.15 Testing for electrotechnical systems.

**What do learners need to learn?**
Tests to be carried out on an electrical installations in accordance with the BS 7671 and IET Guidance Note 3. Identify the appropriate instrument for each test to be carried out in terms of:

- The instrument is fit for purpose
- Identifying the correct scale or setting
- Specifying the requirements for the safe use of instruments to be used for testing and commissioning.

Why it is necessary for test results to comply with standard values. State the actions to be taken in the event of unsatisfactory results being obtained. Explain why certain testing is carried out in the sequence specified in BS 7671 and IET Guidance Note 3.
1.16 Equipment adjustments as required by installation standards to ensure correct function.

**What do learners need to learn?**

Standard procedures and processes for how to adjust and alter settings associated with electrical components in accordance with manufacturers requirements and operation system instructions when carrying out the commissioning of the installation — for example adjusting settings as required. How this information is recorded and conveyed to stakeholders during the handover process.

**System maintenance (PO4)**

1.17 Types of electrotechnical **system maintenance**.

**Range:**

System maintenance - planned and preventative maintenance (PPM), reactive

**What do learners need to learn?**

Legal requirements relating to PPM, responsibilities for undertaking maintenance regimes.

Advantages and limitations of PPM and reactive maintenance.

Requirements for completing documentation and updating O&M manuals.

1.18 **Fault finding** and rectification techniques.

**Range:**

Fault finding techniques - identification of symptoms, collection and analysis of data, use of sources/types of information (e.g. circuit schedules, installation specifications, drawings/diagrams), determining nature/characteristics of faults through discussion and questioning, checking and testing, analysis of results/information.

Rectification techniques - repair, replace, adjust.

**What do learners need to learn?**

Safe working procedures following evaluation and application of appropriate and logical fault diagnosis methods and techniques.

Diagnosis of electrical faults using engineering decisions and evaluation of symptoms and findings. Appropriate and efficient action/s that should be recommended to rectify faults.
1.19 Maintenance requirements for different **building types** and locations.

**Range:**

**Building types** - private, commercial, HMO’s, residential.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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</thead>
<tbody>
<tr>
<td>Regulations concerning set systems to put in place in relation to different types of premises.</td>
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</tr>
<tr>
<td>Some types of buildings are covered by specific, specialist regulations and control measures e.g. hospitals, chemical plants, paint stores etc.</td>
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</tbody>
</table>

1.20 Maintenance of older systems and installations.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification of older systems that may not be compliant with current regulations and reporting on condition and suitability for continued use.</td>
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</tbody>
</table>

**System decommissioning (PO5)**

1.20 Ways of making systems safe to decommission.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation of system from the supply source or outgoing service, turn off the electrical supply.</td>
<td></td>
</tr>
<tr>
<td>Handling materials to protect their integrity and safety during decommissioning.</td>
<td></td>
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<tr>
<td>Removal of pre-installed components from electrical installations.</td>
<td></td>
</tr>
<tr>
<td>Reconfiguration of electrical installations during the decommissioning process. Categorisation of waste produced during the decommissioning process.</td>
<td></td>
</tr>
<tr>
<td>Use of construction materials to make good the building fabric following installation component removal.</td>
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</tbody>
</table>
1.21 Methods of identifying potential issues before decommissioning systems.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods including reviewing O&amp;M manuals, consultation of component data sheets and drawings. Benefits of devising a timely plan when decommissioning systems.</td>
<td></td>
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</tbody>
</table>
### Performance outcome 2 - Install electrotechnical systems

#### 2.1 Assess risk associated with tasks.

**What do learners need to learn?**

Assessment of risk **may** relate to the production or review of a risk assessment for installation activities, with consideration of specialist equipment required.

Risks will vary depending on system being installed but may include for example whether any specialist equipment is needed etc.

Consideration should be made with reference to recording of risk assessment findings in line with regulations as well as responsibilities of employees vs employers.

**Skills**

#### 2.1 Collect and collate information required to complete tasks.

**Range**

**Information** - manufacturer’s instructions, Building Regulations, drawings, BS EN standards, data sheets.

**What do learners need to learn?**

Interpreting data from sources in order to correctly carry out installation processes. As part of this the importance of reference to currency of standards and guidance documents, and whether they are subject to change. Information may include drawings and plans or any relevant information as identified in the range and will relate to the contract/required system.

Review information to ensure its accuracy and validity, including suitability of equipment being installed.

Referring to design specifications and manufacturer data sheets with specific criteria regarding equipment and components required in a system.

**Skills**
2.3 Select tools, equipment and materials to complete tasks.

Range:
Tasks - installing wiring, containment systems and connecting equipment.

What do learners need to learn?  
Selecting the correct materials and hand/power tools or specialist equipment required to complete work activities, taking into consideration the safe use of the equipment and suitability of tools and equipment matched to specific task.

Skills

2.4 Design installation suitable for client’s specification and in accordance with national standards

Design – Current capacity, voltage drop, earth fault paths, earth fault loop impedances, fault condition thermal constraints.

What do learners need to learn?  
Design installations in accordance with BS 7671 and guidance notes. Installation circuits and protection suitable for current carrying capacity, voltage drop limitations, earth fault paths, earth fault loop impedance values and maximum values, selection of protective devices based on data and load conditions, protective conductor selection based on data such as thermal constraints and installation conditions.

Skills

2.4 Inspect the suitability of resources for use, including tools, materials and equipment.

What do learners need to learn?  
Inspecting and using hand and power tools safely – using specific tools required to complete different parts of tasks as required. Power tools, plant and equipment checked in accordance with current statutory, non-statutory regulations and codes of practice.

Skills
2.5 Analyse situations to identify potential causes for delays and errors.

**What do learners need to learn?**

Delays and errors may include the work site not being ready, having incorrect drawings, insufficient materials etc.

Learners should review available progress plans such as Gantt charts/critical path analysis tracking, as well as site meetings to discuss progress detailing any causes for concerns.

**Skills**

2.6 Mark out the position of electrical equipment.

**What do learners need to learn?**

Positioning and securing component locations in line with specification requirements and current industry standards/working methods. When positioning, consideration should be taken of plans/drawings, Building Regulations, manufacturer’s instructions and British Standards.

Considerations given to influences from other installed equipment such as heat producing equipment, steam or external influences such as direct sunlight.

Appropriate fixings must be used to ensure security of components and checks should be made to ensure components are level and secure following positioning.

**Skills**

2.7 Use tools, equipment and materials to carry out tasks.

**What do learners need to learn?**

Setting up and using the correct hand and power tools, plant and equipment required to complete work activities, taking into consideration the safe use of the equipment and suitability of tools and equipment, including suitable PPE, matched to specific tasks.
2.8 Install cable containment systems.

What do learners need to learn?

Engineering cable containment installations – to include measuring and cutting of materials needed to required length as detailed in the job specification.

Materials should be cut using appropriate cutting equipment with consideration of safety, materials and equipment available. Consideration should also be made of site restrictions such as space and potential mess when cutting.

Handling materials such as metal and plastic containment systems and different cable types. When handling, relevant PPE must be worn and selected, as well as the reviewing of material data sheets, where information given must be followed to ensure the safety of the user and correct installation of components.

2.9 Install cabling.

What do learners need to learn?

Install cables within containment systems or on support systems using appropriate methods for drawing in, laying and securing. Suitable considerations given to protection of cables during installation.

2.10 Connect electrical equipment to installed wiring systems.

What do learners need to learn?

Connecting/fixing electrotechnical system components together using appropriate methods of fixing as listed in the design specification/manufacturers details with consideration of material type, materials, and equipment reviewing safety requirements.

Appropriate fixings must be used to ensure security of components and checks should be made to ensure components are level and secure following positioning.
2.11 Terminate cables and connect conductors.

**What do learners need to learn?**
Terminating and securing the connection of conductors in line with specification requirements and current industry standards/working methods.

When securing terminations/connections consideration should be taken of external influences, Building Regulations, manufacturer’s instructions and British Standards.

Appropriate connections/terminations must be used to ensure security of connection/termination types and checks should be made to ensure termination/connections are level and secure.

---

2.12 Measure and evaluate circuit conditions for differing **load profiles**

**Load profiles** – inductive, resistive, capacitive, reactive, power factor, power factor correction.

**What do learners need to learn?**
Use of measuring and monitoring equipment to determine and analyse different types of load and the effects of load on circuit conditions such as current and voltage. Analyse power factor and determine suitable measures to minimize impact of reactance on circuit conditions.

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2.13 Select suitable lighting lamps and luminaires for **environment and usage**

**Environment and usage** - statutory levels of illuminance, glare, utilisation factors, photometric data, conditions of evacuation, external influences, colour rendering.

**What do learners need to learn?**
Select suitable types of lighting lamp and luminaire for given conditions such as intended use and location. Consider factors affecting selection such as space-height ratio, manufacturers’ photometric data, conditions of evacuation, energy efficiency, colour rendering.
Performance outcome 3 - Commission electrotechnical systems

3.1 Prepare for inspection, testing and commissioning.

**What do learners need to learn?**

Gathering the information necessary for detailed inspection, testing and commissioning of electrical installations including manufacturers data, design information, tolerances, drawings and charts.

**Skills**

3.2 Inspect electrotechnical systems.

**What do learners need to learn?**

Completing visual inspections as per relevant electrical inspection schedules used in accordance with BS 7671 and IET Guidance Note 3.

**Skills**

3.3 Test electrotechnical systems.

**What do learners need to learn?**

Tests to be carried out on an electrical installation in accordance with BS 7671 and IET Guidance Note 3, for example tests for continuity of conductors, insulation resistance, polarity and earth fault loop impedance.

Learners must select the appropriate instrument for each test to be carried out in terms of:

- Ensuring the instrument is fit for purpose
- Identifying the correct scale or setting

Why it is necessary for test results to comply with standard values and actions to be taken in the event of unsatisfactory results being obtained.

**Skills**

3.4 Analyse and interpret information and data.

**What do learners need to learn?**

Interpreting information obtained from digital sources and from testing electrotechnical systems. Analysis and interpretation may involve the use of computer programs and packages and reviewing project management literature and plans.

**Skills**
3.5 Complete commissioning **documentation**.

**Range:**
**Documentation** - Electrical Installation Certificate, Minor Electrical Installation Minor Works Certificate, Schedule of Inspections, Schedule of Test results.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completing all relevant sections/information that must be contained on initial verification documentation. Following certification processes for a completed installation, with consideration of the responsibilities of relevant personnel in relation to the completion of the certification process.</td>
<td></td>
</tr>
<tr>
<td>Learners must follow requirements for the recording and retention of completed initial verification documentation in accordance with BS 7671. Ensuring O&amp;M manuals are complete and reflect the 'as fitted' work undertaken. Information handed over to stakeholders.</td>
<td></td>
</tr>
</tbody>
</table>
Performance outcome 4 - Maintain electrotechnical systems

4.1 Communicate health and safety risks to stakeholders orally.

**What do learners need to learn?**

Communicating with stakeholders in line with system maintenance undertaken for example explaining unsafe situations and risks associated with them. Communications may relate to the production of a risk assessment for maintenance activities.

Explaining relevant content of the risk assessment to stakeholders.

**Skills**

4.2 Sequence activities required to complete task including planning to isolate electrical supplies and informing relevant people.

**What do learners need to learn?**

Following correct sequence of activities to complete a maintenance task:

- Selecting tools/equipment
- Obtaining method statement/work order
- Carrying out safe and secure isolation (including getting permission to isolate)
- Carrying out maintenance activities
- Removing isolation
- Functional testing

**Skills**

4.3 Allocate time and resources to complete the task including materials required.

**What do learners need to learn?**

Reviewing sequence as detailed in 4.2 depth with application of appropriate timings for each stage.

Liaison with stakeholders to agree timings to minimise disruption and enhance safety.

**Skills**
4.4 Collect and record electrical installation data.

**What do learners need to learn?**
Collecting relevant electrical installation data. Electrical installation data may include work records or equipment maintenance sheets etc. Familiarity with records of work, including preventative maintenance and reactive maintenance requirements.

Inspection and test schedules may be company or system specific, so awareness needed of documentation required to be completed for maintenance activities.

**Skills**

4.5 Analyse data from work activity.

**What do learners need to learn?**
Interpreting figures and values obtained from electrical installations (e.g. generated diagnostic reports,) in order to evaluate the condition of the electrical installation, and complete appropriate documents.

Relevant documentation should be populated with values and comments relating to set task or activity undertaken.

**Skills**

4.6 Provide technical advice and guidance to technical and non-technical stakeholders.

**What do learners need to learn?**
Conveying information for example safety considerations, maintenance requirements etc. to inform and educate stakeholders with a specific focus on ensuring all stakeholders are aware of health and safety responsibilities.

Learners must be able to overcome potential barriers to successful communication with specific reference to language and methods used for both technical and non-technical stakeholders.

**Skills**

4.7 Test electrical installation to ensure it is safe to work on.

**What do learners need to learn?**
Carrying out checks to ensure safe isolation has been carried out correctly and that any stored charge within the equipment has been discharged.

**Skills**
4.8 Analyse information to identify potential faults.

**What do learners need to learn?**

Inspection for potential faults on installation components through visual inspection of electrical installation, operational checks, feedback from users and performance testing to gather information to be used as part of analysis of situation.

Collating all available information and analysing regarding any possible or potential faults. Reference may also be made to manufacturer’s instructions or specifications (e.g. fault finding flow chart).

**Skills**

4.9 Think creatively to propose solutions for installation faults.

**What do learners need to learn?**

Installation faults and issues may include insulation resistance readings deteriorating over time and having contingency plans in place for equipment that is no longer manufactured etc.

Site inventory is required with all equipment details assigned including age. Storage of spare parts is required for equipment and parts of the electrical installation that may fail due to a number of reasons.

Contingency budget planning needs to be reviewed regularly with consideration given to performance levels of existing equipment and plant.

**Skills**

4.10 Replace **components** of electrotechnical systems.

**Range:**
**Components** - lamps, tubes, accessories, wiring, containment, devices

**What do learners need to learn?**

Replacing components within an electrical installation as necessary to meet industry and task specific requirements. Consideration should be made to safe/appropriate disposal of replaced components and ensuring all work has been recorded for records of work and O&M manuals.

**Skills**
Performance outcome 5 - Decommission electrotechnical systems

5.1 Communicate with relevant stakeholders to ensure required information is available to undertake the task using electronic communication.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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<tbody>
<tr>
<td>Systems used in the tracking and monitoring of site/contract progress. This may include software packages (word processing, email, spreadsheets etc.).</td>
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</table>

5.2 Make systems safe to work on including safe and secure isolation and discharging stored charge.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrying out safe isolation procedures and ensuring that the electrical installations is discharged before commencing work on decommissioning.</td>
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</tbody>
</table>

5.3 Remove electrotechnical systems.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removing all redundant equipment and wiring of the electrical installation with consideration of categorising waste produced during the decommissioning process. Using construction materials to make good the building fabric following component or system removal. Updating and changing records to reflect work undertaken.</td>
<td></td>
</tr>
</tbody>
</table>
Electrotechnical

Links to Maths, English and Digital Skills

Maths
- Measurement of site requirements involving calculations e.g. of area and length (2.8)
- Processing data from systems analysis, calculating values and identifying potential errors (3.4, 4.5)

English
- Reviewing principles of national standards as documented in current regulations (1.3, 1.4)
- Reviewing and interpreting risk assessment documentation with consideration of accuracy and legibility in line with legislation requirements (2.1)
- Selecting, comparing, and analysing relevant texts/documents/sources and using them to gather information (2.2)
- Completing system commissioning documentation in line with requirements of industry standards (3.5)
- Presenting information and ideas clearly and persuasively to others with appropriate language, overcoming potential barriers (4.1, 4.6)

Digital
- Accessing, navigating and searching for information using internet search tools – e.g. using appropriate search techniques and design queries to locate information on older systems (1.17)
- Reviewing system installation plans and data using specific software packages (4.4, 4.5)
- Using systems for tracking and monitoring progress (5.1)

Core content
All aspects of the common core and BSE specific core content can be related and contextualised on delivery in relation to this specialism. However, the following are key areas of the content that may be of particular relevance when delivering the knowledge and practical content for this specialism and may provide efficiencies for teaching core knowledge in context:

Common core content
- Construction science principles – Electricity, heat
- Construction sustainability principles - Energy production and energy use
- Building technology principles - Internet of things
- Construction information and data principles - Key elements of data

BSE specific core content
- Digital technology in construction - Internet of things, digital engineering techniques, opportunities for the use of technology used in other industries and contexts and adapting for use in construction and the built environment
- Health and safety - BSE Regulations, safe working practices for the safe isolation of systems
- Building Services Engineering (BSE) systems - Electrotechnical principles of components, types of control systems, types of monitoring systems, types of electrical
supply, types of earthing arrangements, cable types and sizes, accessories and equipment used in older electrical installations

- Information and data - Drawings, circuit diagrams and schematics, data storage, security and protection, programming and set up of digital systems using IT resources

**Links to Core Skills**

As part of delivery of the skills and knowledge within this specialism reference should be made to criteria that support the development of the four core skills – communication, working collaboratively, problem solving and research. Some examples of criteria that may be linked to supporting these core skills include:

- Communication e.g. providing information and advice to customers and / or wider stakeholders on the potential risks of a change to an industrial system or making a presentation to a stakeholder on the implications of change.

  **Example criteria**
  - 4.1 Communicate health and safety risks to stakeholders orally.
  - 4.6 Provide technical advice and guidance to technical and non-technical stakeholders.
  - 5.1 Communicate with relevant stakeholders to ensure required information is available to undertake the task using electronic communication.

- Working collaboratively with other team members and stakeholders e.g. to develop content to bid for a construction project.

  **Example criteria**
  - 4.6 Provide technical advice and guidance to technical and non-technical stakeholders.

- Applying a logical approach to solving problems, identifying issues and proposing solutions e.g. through setting criteria for successful implementation of a system, using cost / benefit analysis of the introduction of new procedures or equipment.

  **Example criteria**
  - 2.5 Analyse situations to identify potential causes for delays and errors.
  - 3.4 Analyse and interpret information and data.
  - 4.5 Analyse data from work activity.
  - 4.8 Analyse information to identify potential faults.
  - 4.9 Think creatively to propose solutions for installation faults.

- Conducting primary research e.g. obtaining measurements related to a design or customer requirements.

  **Example criteria**
  - 2.2 Collect and collate information required to complete tasks.
  - 2.6 Mark out the position of electrical equipment.
Guidance for delivery

- Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery
- Formative assessment – oral Q&A, SmartScreen worksheets (samples available) observation of measuring activities
  - Practical - Use of pre-set formative assessments to carry out tasks and record on standardised form.
  - Knowledge – pre-set paper-based activity to confirm skills and understanding.
    Learners can use variety of methods to carry out activities, calculators, apps, office IT
- Ways of ensuring content is delivered in line with current, up to date industry practice
  - Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
  - Teaching coverage must represent the type of equipment currently available and accepted for use in the UK industry
  - Current and emerging electrical installation and testing technologies should be included in the delivery where possible
- Reinforcement of learning – revisiting learning, group discussions, peer support system

Suggested learning resources

Books

- The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)
  Author: Peter Tanner
  Publisher: Hodder Education (28 Sept. 2018)
- The City & Guilds Textbook: Book 2 Electrical Installations for the Level 3 Apprenticeship (5357), Level 3 Advanced Technical Diploma (8202) & Level 3 Diploma (2365)
  Author: Peter Tanner
  Publisher: Hodder Education (25 Jan. 2019)
- Requirements for Electrical Installations, IET Wiring Regulations, Eighteenth Edition, BS 7671:2018 (Electrical Regulations)
  Author: The Institution of Engineering and Technology
  Publisher: Institution of Engineering and Technology; 18th Edition (2 July 2018)

Websites

- Institute for apprenticeships and technical education
  https://www.instituteforapprenticeships.org/
- National Careers Service
  https://nationalcareers.service.gov.uk/job-profiles/electrician
- Electrical Contractors’ Association (ECA)
  https://www.eca.co.uk/
- Institute of Engineering and Technology (IET)
  https://electrical.theiet.org/bs-7671/
- Health and Safety Executive
  https://www.hse.gov.uk/electricity/
• Safety Electrical First- https://www.electricalsafetyfirst.org.uk/
• Electrical Times- https://www.electricaltimes.co.uk/
• Sparks magazine (for trainees)- https://www.sparks-magazine.co.uk/
• Electrical Trade Magazine- https://www.electricaltrademagazine.co.uk/
354  Gas engineering

<table>
<thead>
<tr>
<th>Level:</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLH:</td>
<td>440 (tbc)</td>
</tr>
<tr>
<td>Assessment method:</td>
<td>Practical assignment</td>
</tr>
</tbody>
</table>

**What is this specialism about?**

The purpose of this specialism is for learners to understand and undertake fundamental gas engineering work. Learners will have the opportunity to plan, perform and evaluate their work whilst utilising a range of materials, methods and techniques.

Learners will develop their knowledge and understanding of, and skills in:

- Fundamental safe working practices associated with gas engineering
- Tools and equipment associated with the installation of gas systems
- Installation, maintenance, repair and service requirements of gas systems and appliances
- Scientific principles used in gas engineering
- Measuring and marking of components and pipework

Learners may be introduced to this specialism by asking themselves questions such as:

- What does a gas engineer do?
- What tools and equipment do gas engineers use as part of their role?
- What are the steps required to become a qualified gas engineer?

**Underpinning knowledge outcomes**

On completion of this specialism, learners will understand:

1. Gas knowledge criteria

**Performance outcomes**

On completion of this specialism, learners will be able to:

2. Install gas systems
3. Commission gas systems
4. Maintain gas systems
5. Decommission gas systems

Completion of this specialism will give learners the opportunity to develop their Maths, English and Digital Skills. Details are presented at the end of the specification.
## Specialism content

### Common knowledge criteria

**Health and safety**

1.1 **Typical hazards** and risks associated with working with gas systems.

**Range:**

**Typical hazards** - asbestos, explosions, carbon monoxide poisoning, slips and trips, manual handling, working at heights, burns, dust, electrocution

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The different hazards that are associated with working with gas systems and how to negate the risks.</td>
<td>EC3 EC5</td>
</tr>
</tbody>
</table>

1.2 Safe working practices associated with working with gas systems.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe working practices associated with working with gas systems including: Building Regulations, documents (risk assessments and method statements) and PPE.</td>
<td>EC3 EC5</td>
</tr>
</tbody>
</table>

1.3 **Emergency procedures** for unsafe situations.

**Range:**


**Unsafe situations** - gas leaks, explosions, carbon monoxide poisoning.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsafe situations that may occur in the workplace and the correct procedures and reference documents to use if they do arise.</td>
<td>EC5</td>
</tr>
<tr>
<td>Understand when unsafe situations need to be reported with consideration of, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR).</td>
<td>EC5</td>
</tr>
</tbody>
</table>
Tools, equipment and materials
1.4 Types of tools, equipment and materials.

Range:
Tools and equipment - manometer, combustion performance analyser, leak detector, pipe cutter, hacksaw, blowtorch, spanner, grips, bending machine, drill, hammer, screwdrivers, temporary continuity bonds, step ladders, mobile scaffolding.

What do learners need to learn?  
Tools, equipment and materials, their correct method of use and when they should be used e.g. for access, measuring when working on gas systems.

The characteristics and properties of different tools, equipment and materials and what makes them more suitable for different tasks.

Skills

1.5 Operation and handling requirements of tools, equipment and materials.

Range:
Tools and equipment - manometer, combustion performance analyser, leak detector, temporary continuity bonds.

What do learners need to learn?  
How tools, equipment and materials are maintained and stored to minimise damage and maximise longevity of use. The processes for maintaining and re-calibrating equipment and the implications of not following these processes correctly.

Skills
Gas systems

1.6 Types of components and their suitability for different appliances and types of systems.

Range:
**Components** – fan, zero rated governor, thermistors, printed circuit board, Wheatstone bridge, multi-functional control valve, air pressure switch, thermocouples.

**Appliances** - water heaters, central heating boilers, space heaters, gas meter (G4 and E6).

**Systems** - Natural Gas (NG), Liquefied Petroleum Gas (LPG).

1.7 How components operate within a system/appliance and integrate to enable the system to operate effectively.

Range:
**Components** - fan, zero rated governor, thermistors, printed circuit board, Wheatstone bridge, multi-functional control valve, air pressure switch, thermocouples.

**Appliance** - water heaters, central heating boilers, space heaters, gas meter (G4 and E6)

**What do learners need to learn?**

- Characteristics of Natural Gas and Liquid Petroleum Gas. The requirements of different systems and how different components are suitable for different systems, including:
  - Correct gas type for appliance being installed
  - Calorific values
  - Heat output
  - Freezing temperatures
  - Relative densities
  - Wobbe numbers

With reference to manufacturer’s instructions

**Skills EC5**

1.7 How components operate within a system/appliance and integrate to enable the system to operate effectively.

Range:
**Components** - fan, zero rated governor, thermistors, printed circuit board, Wheatstone bridge, multi-functional control valve, air pressure switch, thermocouples.

**Appliance** - water heaters, central heating boilers, space heaters, gas meter (G4 and E6)

**What do learners need to learn?**

- Components within a gas appliance/system, how they interact with each other to control the temperature of heated water, operational periods and safe combustion of the gas.

**Skills**
### 1.8 Factors

Factors that affect the choice and suitability of components included in a system.

**Range:**
- **Factors** - location, gas type, appliance type, size, Gas Council number, legislation, environmental/efficiency

**What do learners need to learn?**

Characteristics of components in a system and how these affect choice and suitability.

### 1.9 Waste and **waste products**.

**Range:**
- **Waste products** - carbon monoxide, carbon dioxide, condensate.

**What do learners need to learn?**

Waste produced within a gas heating system and how these inform servicing and maintenance schedules for the gas system/appliance.

### 1.10 Safety devices

Safety devices applicable to gas systems, their characteristics and operation.

**Range:**
- **Safety devices** - carbon monoxide detectors, Under pressure shut off valves (UPSO), Over pressure shut off valves (OPSO), Safety Shut Off Valves (SSOV), emergency Control Valves (ECV), air pressure switches, low water pressure switches, overheat thermostats, thermocouples.

**What do learners need to learn?**

Safety devices used in gas systems/appliances, their testing procedures and how to replace if faulty, to ensure safe use of the appliance/system.

### 1.11 Gas and the combustion process.

**What do learners need to learn?**

The combustion process and analysis including complete and incomplete combustion, the by-products (i.e., Carbon Dioxide (CO2) levels Carbon monoxide (CO) levels Oxygen (O2) levels) of combustion and their trigger values.

Types of burners (simplex and duplex) and interaction with other devices e.g. ventilators and Mechanical Heat Ventilation Recovery (MHVR) etc.
1.12 Mechanical Heat Ventilation Recovery (MHVR).

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Heat Recovery and Ventilation system. The method of extracting useable heat from the ambient air to further reduce heating costs - Flue gas recycling.</td>
<td></td>
</tr>
<tr>
<td>The combustion process, their correct operation, safe operation and suitability for different types of system.</td>
<td></td>
</tr>
</tbody>
</table>

1.13 **Types of flues** in relation to gas.

**Range:**
Types of flues - open flued, room sealed, flueless

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The fundamental operating principles of the various flueing systems, their testing requirements and their suitability for different appliances.</td>
<td></td>
</tr>
</tbody>
</table>

1.14 **Types of ventilation** in relation to gas.

**Range:**
Types of ventilation - permanently open, closeable, flyscreen, terracotta, unsleeved, incomplete, cooling air, high/low level ventilation, compartment ventilation, open flued ventilation calculations, room sealed ventilation requirements, ventilation through two or more rooms, mechanical ventilation

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The types of ventilation and their requirements for each fuel, flue type and appliance.</td>
<td></td>
</tr>
</tbody>
</table>

1.15 Types of **gas appliances** and their system requirements.

**Range:**
Gas appliances - water heaters, central heating boilers, space heaters, gas meter (G4 and E6)

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different gas burning appliances and their system requirements.</td>
<td></td>
</tr>
</tbody>
</table>
Gas engineering science
1.16 Scientific principles and concepts as applied to gas engineering.

Range:
Scientific principles - complete combustion, incomplete combustion, stoichiometric combustion, fuels, chemical, smouldering, diffusion, rapid, spontaneous, explosive

Concepts - ventilation, flue draft, fuels

What do learners need to learn?  
Scientific principles of combustion and the effects these can have on the combustion process.

Skills

Pipework technology
1.17 Types of pipework.

Range:
Pipework - copper pipework, LCS pipework, plastic pipework

What do learners need to learn?  
Characteristics of different types of pipework, including prefabricated and modularised components and distribution systems, different sizes, types of materials, their suitability for different situations and tools and equipment (including fixings) required.

Fittings and components and their use for different piping scenarios. The types of fixings available for the different materials.

Skills

1.18 Flow rates and their relationship to pipework and system design.

What do learners need to learn?  
Different pipework materials, fittings and components and their effects on pressure and flow of the gas. The detrimental effect that pressure loss can have on the combustion of gas if too large.

Skills
1.19 Different **techniques** for forming and bending pipework.

**Range:**
**Techniques** - bending machine, bending spring

**Legislation and industry guidance**

**What do learners need to learn?**
The different techniques for forming and bending pipework and how these are applied during the installation of gas systems/appliances.

1.20 Implications of **legislation** and additional **guidance** to employers and those working with gas systems.

**Range:**

**Guidance** - Gas Safe magazine, gas safe technical bulletins, manufacturer’s literature

**What do learners need to learn?**
Legislation and additional guidance for installation of systems and the implications of these to employers and end users.

**Building technology**
1.21 Types of **fixtures** and suitability for different **building fabrics**.

**Range:**
**Fixtures** - screws, nails, plasterboard fixings, toggle bolts, fischer bolts, security bolts
**Building fabrics** - block walls, brick walls, wooden partitions, plasterboard walls

**What do learners need to learn?**
The various types of fixings, and their suitability for different building materials.
### Specific knowledge criteria for performance outcomes

#### System installation (PO2)

1.22 Bending techniques.

**Range:**
**Bending techniques** - machine, scissor, hand bender, spring

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of bending techniques and the different tasks these may be used for.</td>
<td></td>
</tr>
</tbody>
</table>

1.23 Connection techniques.

**Range:**
**Connection techniques** - threading, soldering, compression, press-fit, PTFE, jointing compound

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of jointing methods and processes and how to transition from one pipework material to another.</td>
<td></td>
</tr>
</tbody>
</table>

#### System commissioning (PO3)

1.24 Inspection techniques and how they are applied in commissioning systems.

**Range:**
**Inspection techniques** - visual inspection.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The factors to inspect during a visual inspection in line with manufacturer's literature.</td>
<td>EC5</td>
</tr>
</tbody>
</table>
1.25 Factors to inspect during commissioning and how expected standards are defined.

Range:
Factors - flow rate, temperature rise (Delta T), combustion analysis, gas rate, working pressure, standing pressure, operating/ burner pressure, appliance condition, ventilation requirements, flueing requirements.

What do learners need to learn?  
Factors to inspect during commissioning. How to interpret results and findings from commissioning tests. How expected standards are defined (manufactures instructions) and what actions to take if appliance/system is not functioning as expected.

Skills  
MC2  
MC6

1.26 Testing of installation.

Range:
Testing - tightness test, let-by test, flue flow test, spillage test, ventilation check.

What do learners need to learn?  
Critical testing that needs to be completed as part of installation and commissioning.

Skills

1.27 Safe storage and supply of fuel source.

Range:
Safe storage – bottled, bulk storage  
Fuel source - Natural Gas, LPG

What do learners need to learn?  
The safe storage and safe supply of natural gas and LPG.

Skills

System maintenance (PO4)

1.28 Cleaning of components without compromising the system and associated tools, equipment and materials.

What do learners need to learn?  
Cleaning and servicing with consideration of appropriate, technique, tools and process in line with and manufactures recommendations and servicing schedules.

Skills  
EC5
1.29 **Fault finding techniques**, their suitability for different situations and how they are applied in practice.

**Range:**

**Fault finding techniques** - resistance testing with a multimeter, testing switches with a multimeter, voltage testing with a multimeter, pressure testing, checking flow rates, reading manufacturers fault finding charts, questioning end user, researching the internet, industry knowledge.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
</table>
| The process for carrying out Fault-finding techniques and which techniques are suitable for different situations and how planned maintenance activities can minimise faults. | EC5
| | MC2
| | DC1
| | DC5

### Decommissioning (PO5)

1.30 Procedures involved in decommissioning.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
</table>
| The processes and procedures involved in decommissioning gas systems. | EC5
| | MC2
| | DC1
| | DC5

1.31 Requirements for recording, labelling and reporting decommissioned systems.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
</table>
| Requirements for each system to record, label and report decommissioned systems to prevent the use of decommissioned appliance to include: | EC1
| | EC3
| | EC4
| | EC6

- Informing the responsible person
- Warning notices
- Labels
Performance outcome 2 - Install gas systems

2.1 Interpret information from a risk assessment.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review and interpret risk assessments following HSE Guidance. Consideration of employees vs employees’ responsibilities in relation to risk assessment completion.</td>
<td>EC4, EC5</td>
</tr>
</tbody>
</table>

2.2 Use **tools** in accordance with good working practice.

**Range:**
**Tools** - screwdriver, hammer, wood chisel, grips, spanner, spirit level, manual pipe threader, pipe cutter, pipe slice, hand saw, pliers, bending machine, blow torch, drill.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select the correct hand and power tools required to complete work activities on gas systems, taking into consideration the safe use of the equipment and suitability of tools and equipment matched to specific task.</td>
<td></td>
</tr>
</tbody>
</table>

2.3 Install **pipework** relevant to the **type of gas** being conveyed.

**Range:**
**Pipework** - copper pipework/fittings, LCS pipework/fittings, CSST tube/fittings.
**Type of gas** - LPG, Natural gas.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install Gas pipework within or on the building fabric in line with industry standards, Building Regulations and safe working practices.</td>
<td>MC1</td>
</tr>
</tbody>
</table>
2.4 Install **clips/brackets** to various **substrates**.

**Range:**
**Clips/brackets** - nail-on clip, plastic standoff, brass munsen ring, LCS munsen ring, meter brackets, flue brackets

**Substrates** – wood, brick, masonry

**What do learners need to learn?**
Fix clips and brackets at recommended spacing intervals to meet the specification requirements and in line with current industry standards.

**Skills**
MC1

2.5 Install **flues/chimneys** to facilitate a range of **gas appliances** and equipment.

**Range:**
**Flues** - open flues, room sealed flues
**Gas appliances** - open flued appliances, room sealed appliances, flueless appliances

**What do learners need to learn?**
Install a selection of flue types to different locations in line with Gas and Building Regulations and manufacturer’s instructions, including the use of terminal guards as required.

**Skills**
MC1

2.6 Install ventilators to facilitate the correct combustible air requirements for **appliances** installed in a variety of **locations/buildings**.

**Range:**
**Locations/buildings** - cavity walls, high level, low level, through two or more rooms
**Appliances** - space heater, boiler, water heater, gas cooker

**What do learners need to learn?**
Install ventilators to different building substrates ensuring that they are adequately sized and of the correct design for the type and size of appliance and fuel type.

**Skills**
MC1
2.7 Install **appliances**.

**Range:**
**Appliances** - space heater, boiler, water heater

**What do learners need to learn?**
Install gas appliances in line with manufacturer instructions following all installation instructions.

**Skills**
MC1

2.8 Install **components** into appliances.

**Range:**
**Components** - multi-functional control valve/ Gas valve, fan, burner, pressure relief valve, automatic air vent, printed Circuit Board, air pressure switch.

**What do learners need to learn?**
Install a range of components into gas appliances.

**Skills**

2.9 Install **controls** into systems.

**Range:**
**Controls** - programmer, room thermostat, cylinder thermostat.

**What do learners need to learn?**
Install control components into a central heating system.

**Skills**
DC6

2.10 Install **thermal insulation materials**.

**Range:**
**Thermal insulation materials** - polyisocyanurate foam, PVC foam, polyethylene foam

**What do learners need to learn?**
Install various thermal insulation to prevent the freezing of system pipework.

**Skills**
2.11 Install **seals** appropriate to the gas **appliance**.

**Range:**
**Seals** - burner seals, gas seals, water seals  
**Appliances** - space heater, boiler, water heater

**What do learners need to learn?**
Check the condition of and replace different types of seal found in a gas appliance from a selection of seals.

2.12 Check **gas components** are in accordance with **design parameters**.

**Range:**
**Gas components** - thermistors, zero governors, thermostats, combustion performance analysis, gas valves.

**Design parameters** - resistance readings, pressure settings, temperature range, acceptable levels, manufacturer’s parameters.

**What do learners need to learn?**
Use recognised testing methods (multimeters, gas rating, gas pressure testing, etc) to ensure all components are within design parameters.

2.13 Check gas components are registered Gas Council (GC).

**What do learners need to learn?**
Check gas components comply with Gas Council and have their own Gas Council numbers.

2.14 Analyse information to identify **requirements** for gas installation.

**Range:**
**Requirements** - flueing requirements, ventilation requirements, pipe sizing requirements, heat output requirements.

**What do learners need to learn?**
Analyse customer requirements to identify the size of gas pipework and appliances to meet possible demand.
2.15 Communicate **system requirements** to allied trades.

**Range:**
**System requirements** - electrical control requirements, hot and cold pipework layout, heating system pipework layout

**What do learners need to learn?**
Identify and communicate with other trades, detailing timescales and other system requirements.

**Skills**
- EC1
- EC2
- EC6

2.16 Establish **safe working environment** to conduct gas installation.

**Range:**
**Safe working environment** - well ventilated area, no ignition sources, good housekeeping, removal of meter, continuity of earth, liaise with end user.

**What do learners need to learn?**
Create a safe and clean working environment when installing gas systems and appliances, eg good housekeeping, etc.

**What do learners need to learn?**
Install system pipework, use appropriate methods to ensure no foreign objects enter the gas system. Complete cleaning of gas filters and gauzes ensuring; No open-ended pipework and good housekeeping

**Skills**
- MC1
- MC2
- MC6
- EC1
- EC2
- EC3
- DC5

2.17 Ensure no ingress of foreign objects within gas system and component.

**What do learners need to learn?**
Complete a schematic diagram of a gas carcass in a property, complete with pipe sizing and appliance gas rates.
2.19 Complete a method statement for installation and identifying any potential delays.

**What do learners need to learn?**

Complete a method statement, identify the possibility of delays and unforeseen circumstances and put systems in place to minimise risks.

**Skills**

| EC1 | EC2 | EC3 | MC1 | MC2 | MC10 |

2.20 Adapt on-site specific gas system installation changes.

**What do learners need to learn?**

The learner is to be tested on the necessary changes that need to be made if an appliance is to be made to burn a different gas type.

- LPG to natural gas etc.
- Injector sizes
- Ventilation requirements
- Notification

**Skills**

| EC1 | EC2 | EC3 | MC1 | MC2 | MC10 |

2.21 Gather relevant gas system component part **information**.

**Range:**

**Information** - manufacturer’s instructions, normative documents, trade magazines, merchants.

**What do learners need to learn?**

Gather relevant documentation for working with gas systems and appliances.

**Skills**

| EC5 | EC6 |

2.22 Update digital building information management system **software**.

**Range:**

**Software** - Autodesk, Revit, AutoCad, BIM 360

**What do learners need to learn?**

Refer to, and update digital building information management system software.

**Skills**

| DC1 | DC2 | DC3 | DC5 | DC6 |
Performance outcome 3 - Commission gas systems

3.1 Assess **risks** associated with completing activities.

**Range:**
**Risks** - explosive atmosphere, carbon Monoxide production, slips, trips and falls, crushing injuries, burns, cuts.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce a risk assessment for commissioning activities in accordance with the five stages of assessment;</td>
<td>EC1 EC2 EC3 EC4</td>
</tr>
<tr>
<td>• Identification of hazards</td>
<td></td>
</tr>
<tr>
<td>• Identification of who is at risk and how</td>
<td></td>
</tr>
<tr>
<td>• Assessment of risk and action</td>
<td></td>
</tr>
<tr>
<td>• Recording of findings</td>
<td></td>
</tr>
<tr>
<td>• Review of risk assessment</td>
<td></td>
</tr>
<tr>
<td>• Take appropriate safety precautions</td>
<td></td>
</tr>
</tbody>
</table>

Record risk assessment findings in line with regulations as well as responsibilities of employee's vs employers.

3.2 Test all gas rates and **pressures** are within regulatory requirements.

**Range:**
**Pressures** – working pressure at the meter, operating pressure at the appliance.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use recognised procedures to calculate the various gas rates and pressures required as well as the gas rate of the appliance. Complete a gas rate and undertake gas pressures.</td>
<td>MC1 MC2 EC5</td>
</tr>
</tbody>
</table>

3.3 Ensure any tools/equipment are calibrated correctly.

**Range:**
**Equipment** – flue gas analyser, digital manometer.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibrate tools and equipment correctly. Consider requirements of electronic testing equipment and check if calibration is required. Calibration certificates.</td>
<td>EC5</td>
</tr>
</tbody>
</table>
3.4 Calculate correct purge volumes in accordance with gas installation.

**What do learners need to learn?**

Calculate purge volume and purge requirements including; Calculate purge requirements to air, calculate purge requirements to burn.

Skills

| MC1 | MC2 |

3.5 Purge system correctly.

**What do learners need to learn?**

Complete a safe purge of a gas installation to all industry standards.

Skills

| EC1 | EC2 | EC3 | EC4 | EC5 |

3.6 Visually inspect installation is compliant with Gas Safety and Use Regulations 1998.

**What do learners need to learn?**

Whilst completing gas work, the learner may encounter various non-conformance with the installation of gas pipework, therefore the learner must identify any faults on a pre-assembled system

- Unsupported pipework
- Pipework not sealed correctly
- Pipework not sleeved
- Sleeve not sealed
- Open ended pipework
- Unsafe fitting
- Undersized pipework

Skills

| MC2 | EC3 | EC4 | EC5 |

3.7 Complete gas system **handover documentation** to end user.

**Range:**

**Handover documentation** - manufacturer’s commissioning log, job sheet

**What do learners need to learn?**

Commission gas appliance/system and complete all commissioning documentation as required by the gas sector.

Skills

| EC1 | EC2 | EC3 | EC4 | EC6 |
3.8 Demonstrate safe operation of gas appliance and controls to the end user.

**What do learners need to learn?**

Instruct the customer on the safe and efficient use of all user controls during the handover process of the appliance/system including emergency actions e.g gas leak and what to do in the event of a carbon monoxide alarm sounding.

**Skills**

EC1  EC6

3.9 Visually check gas system installation conforms to original design requirements.

**What do learners need to learn?**

Complete a visual check of gas system installation during handover/commissioning to the original system design as well as manufacturer/regulatory requirements.

**Skills**

3.10 Set gas system parameters to commission in accordance with manufacturer’s instructions and Gas Safety and Use Regulations 1998.

**What do learners need to learn?**

Test gas system/appliance to ensure all measurements are within manufacturer parameters (pressures, temperature, flow rates, gas rate) and in line with the Gas Installation and Use Regulations 1998. Ensure appliance is commissioned as per manufacturer instructions.

**Skills**

MC1  MC2

3.11 Record commissioning results.

**What do learners need to learn?**

Complete a gas system/appliance commissioning record which is correctly documented using relevant technical terms and values. Record all commissioning checks on commissioning record.

**Skills**

EC3  EC4

3.12 Analyse commissioning results to determine correct gas installation in accordance with original design.

**What do learners need to learn?**

Complete a gas system/appliance commissioning record ensuring that all parameters are within scope for the appliance/system. Evaluate commissioning data to ensure that it falls within Manufacturers parameters.

**Skills**

MC2  MC6
Performance outcome 4 - Maintain gas systems

4.1 Question end user to identify any user concerns.

Range:
User concerns - risk assessments, smell of gas, carbon monoxide alarm sounding, using too much gas, appliance/system not working as intended, leaks, noise.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss maintenance requirements with end user/client with reference to other relevant available source materials – e.g. manufacturer’s instructions/service history documents.</td>
<td>EC1 EC2 EC3 EC4 EC5 EC6 MC2 MC6</td>
</tr>
<tr>
<td>Advise on options for system/component maintenance and how it can best be achieved. Consideration should be made to potential barriers/concerns, how to overcome them as well as to reference of costs, sustainability and timescales.</td>
<td></td>
</tr>
</tbody>
</table>

4.2 Identify the correct replacement parts relevant to the appliance from a selection of similar parts.

Range:
Parts - multi-functional control valve, fan, burner, pump, plate to plate heat exchanger, main heat exchanger, automatic air vent, divertor valve/cartridge, pressure relief valve, automatic air vent, printed circuit board.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select the correct replacement part from a selection of similar replacement parts to be fitted to a gas appliance/system.</td>
<td>MC2 EC1 EC6 DC3 DC5</td>
</tr>
</tbody>
</table>

4.3 Calculate maintenance downtime.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculate maintenance downtime. Inform customer of the expected timescales for completion as well as any unexpected delays including, shipment of the part or additional faults in the system.</td>
<td>MC2 EC1 EC6 DC3 DC5</td>
</tr>
</tbody>
</table>
4.4 Safe handling of all **gas components** when conducting maintenance.

**Range:**
*Gas components* - smart meters, pre-payment meters, fragile components, dangerous components.

**What do learners need to learn?**
Handle gas components carefully when conducting maintenance. In addition, the learner is also to be made aware of the possible injuries that may be sustained while working on gas systems/appliances.

4.5 Identify potential **gas installation system errors** and follow unsafe situations procedure.

**Range:**
*Gas installation system errors* - Undersized pipework, blocked pipework, incorrect pipework material, incorrect fittings used on gas pipework, damaged pipework, signs of spillage, undersized/no ventilation where required, vitiated atmosphere, incorrect flue termination, blocked flue, damaged flue, incorrect clearances, faulty safety devices, faulty safety shut off valve, incorrect gas pressures, incorrect gas rates, incorrect gas type, incorrect flame picture, incorrect parts used.

**What do learners need to learn?**
Identify a range of potential gas installation system errors, take the correct steps to ensure these are rectified following the unsafe situations procedure.

4.6 **Test** system in accordance with end user requirements and **appliance type**.

**Range:**
*Test* - combustion performance analysis, let-by test, stabilisation test, tightness test (NG), soundness test (LPG), gas rate, hot water flow rate, standing pressure test, working Pressure test, incoming pressure test, ventilation check, flue flow test, spillage test, temperature/differential checks (Balancing).

**What do learners need to learn?**
Complete critical testing of gas appliance/installations to ensure safety and compliance with end user requirements.
4.7 Remove and replace **faulty gas system components**.

**Range:**

**Faulty gas system components** - meter governor, zero governor, multi-functional control valve, burner, thermistor, thermostat, overheat stat, printed Circuit Board.

**What do learners need to learn?**

Identify faulty gas system parts and components, remove and replace faulty component with new components in accordance with manufacturer's instructions.

**Skills**

4.8 Repair faulty gas system components.

**What do learners need to learn?**

Repair faulty gas component ensuring that it works to all parameters, repairs to include;

- Blocked gauze on governor
- Thermocouple within a multifunctional valve
- Damaged leads

**Skills**
Performance outcome 5 - Decommission gas systems

5.1 Enable control mechanism from a risk assessment prior to working.

What do learners need to learn?
Complete safe and verified isolation of gas, electricity and water supplies prior to commencing work on gas systems/appliances, including the use of Isolation locks and ‘Do not turn on’ signs.

Skills

5.2 Establishing consumer needs when decommissioning any gas installation.

What do learners need to learn?
Discuss with end user any needs when decommissioning any gas installation. Establish customer requirements, for example to maintain temporary heating system, maintain temporary hot water system.

Skills

EC1
EC3
EC4
EC6
DC3
DC5

5.3 Safely isolate the gas system prior to decommissioning.

Range:
Safely isolate - isolate gas at the Emergency Control valve (ECV), isolate electricity at Mains Consumer unit, isolate water (if required) at isolation point.

What do learners need to learn?
Complete safe and competent isolation procedures for the gas, electric and water supplies when required, to include locking off and the placement of ‘Do Not Turn On’ information signs.

Skills

5.4 Extract gas equipment and components from installation with appropriate handling techniques.

What do learners need to learn?
Complete safe systems of work, risk assessments, method statements and select correct PPE when extracting equipment and components from installation.

Skills
5.5 Reinstate appropriate service post decommissioning.

**What do learners need to learn?**

Reinstate all utilities to the system post installation to facilitate commissioning and handover to include:

- Re-pressurise heating system following a replacement part
- Reinstate gas supply and test
- Reinstate electricity supply and test

**Skills**

5.6 Maintain *safe working area*.

**Range:**

*Safe working area* - well ventilated area, no ignition sources, good housekeeping, correct PPE.

**What do learners need to learn?**

Maintain a safe and clean working environment when installing gas systems and appliances.

**Skills**

5.7 Return clean installation to end user.

**What do learners need to learn?**

Complete handover of gas system/appliance to end user. Clear up any mess and replace any damaged items. Notify end user of safe and efficient use of the system/appliance.

**Skills**

EC1
EC2
EC3
EC4
EC6

5.8 Safe disposal of *waste products* when decommissioning gas system.

**Range:**

*Waste products* - asbestos, dust, packaging, appliance, pipework.

**What do learners need to learn?**

Ensure all waste products are disposed of safely when decommissioning a gas system. Recycle as much waste as possible, remove any non-recyclable waste/hazardous waste and deposit at appropriate waste facility. Clean up any remaining mess.
Gas

Core content
All aspects of the common core and BSE specific core content can be related and contextualised on delivery in relation to this specialism. However, the following are key areas of the content that may be of particular relevance when delivering the knowledge and practical content for this specialism and may provide efficiencies for teaching core knowledge in context;

Common core content
- Construction sustainability principles - Energy production and energy use and waste management
- Building technology principles - Internet of things
- Construction information and data principles – Standards, regulations and guidance

BSE specific core content
- Health and safety - BSE Regulations and safe working practices
- Building Services Engineering (BSE) systems – Boilers and fires
- Maintenance – Boiler service

Links to Core Skills
As part of delivery of the skills and knowledge within this specialism reference should be made to criteria that support the development of the four core skills – communication, working collaboratively, problem solving and research. Some examples of criteria that may be linked to supporting these core skills include;

- Communication e.g. providing information and advice to customers and / or wider stakeholders on the potential risks of a change to an industrial system, or making a presentation to a stakeholder on the implications of change
  Example criteria
  o 2.15/3.7 will support a learner’s personal development in how to communicate with others by communicating detail of handover documentation with end users.

- Work collaboratively with other team members and stakeholders e.g. to develop content to bid for a construction project
  Example criteria
  o 2.15 will support a learner’s personal development in how to work collaboratively by communicating system requirements to allied trades.

- Applying a logical approach to solving problems, identifying issues and proposing solutions e.g. through setting criteria for successful implementation of a system, using cost / benefit analysis of the introduction of new procedures or equipment
  Example criteria
  o 2.19 will support a learner’s personal development in how to apply a logical approach to solving problems by putting systems in place to identify and minimise any potential delays and unforeseen circumstances

- Primary research e.g. obtaining measurements related to a design and / or customer requirements.
  Example criteria
2.22 will support a learner’s personal development in how to research by identifying relevant gas system component part information.

Guidance for delivery

- Opportunities for efficiencies in delivery
- Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery
- Formative assessment – oral Q&A, SmartScreen worksheets (samples available)
  - Observation of measuring activities
  - Practical - Use of pre-set formative assessments carry out tasks and record on standardised form.
  - Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT
- Ways of ensuring content is delivered in line with current, up to date industry practice
  - Delivery for this specialism will take place in a dedicated workshop with a range of gas appliances.
  - A realistic representation of UK gas systems and components should be installed in the workshop
  - Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
  - The provision must represent the type of equipment currently available in the UK gas industry
  - New and emerging gas technology should be included in the delivery e.g. smart controls

Suggested learning resources

Books
- The City and Guilds textbook: Plumbing book 2 for the level 3 Apprenticeship (9189). Level 3 Advanced Technical Diploma (8202) and Level 3 Diploma (6035) (City and Guilds)
- Gas Safe Manuals (Gas Safe)
- Level 3 Gas Engineer: Apprenticeship Training Manual (City and Guilds 2018)
- Gas Installation Technology, RD Treloar, Wiley-Blackwell 2010

Websites
- https://gassafetyshop.co.uk/subcategories/ViperGas
- https://www.gassaferegister.co.uk/sign-in/
- https://shop.bsigroup.com/
- https://igem.org.uk/
What is this specialism about?
The purpose of this specialism is for learners to understand and undertake fundamental heating work. Learners will have the opportunity to plan, perform and evaluate their work whilst utilising a range of materials, methods and techniques.

Learners will develop their knowledge and understanding of, and skills in:

- Fundamental health & safety practices associated with carrying out heating engineering work
- Heating engineering tools and equipment
- Pipework technology
- Heating systems
- Heating engineering science
- Regulations, legislation and industry guidance used in the heating industry

Learners may be introduced to this specialism by asking themselves questions such as:

- What does a heating engineer do?
- What tools and equipment do heating engineers use as part of their role?
- What are the steps required to become a qualified heating engineer?

Underpinning knowledge outcomes
On completion of this specialism, learners will understand:
1. Heating knowledge criteria

Performance outcomes
On completion of this specialism, learners will be able to:
2. Install heating systems
3. Commission heating systems
4. Maintain heating systems
5. Decommission heating systems

Completion of this specialism will give learners the opportunity to develop their Maths, English and Digital Skills. Details are presented at the end of the specification.
## Health and safety

### 1.1 Typical hazards and risks associated with heating systems.

**Range:**

**Typical hazards** - tripping hazards, slipping hazards, inadequate or lack of personal protective equipment, defective (unsafe) equipment, manual handling, working at heights, electrocution, chemical injuries, inhalation.

### What do learners need to learn?

Common hazards and risks across all types of jobs as well as specifics relating to the different stages of heating activities:

- Commissioning
- Installation
- Maintenance
- Decommissioning

The different controls that need to be in place to minimise these occurring.

### Tools, equipment and materials

#### 1.2 Types of tools, equipment and materials used for access and measurement when working on heating systems.

**Range:**

**Access** - step ladders and extension ladders, scaffold, hop up

**Measurement** - tape measure, digital measurement tools

### What do learners need to learn?

Common access and measuring equipment, their characteristics, properties, purpose and suitability for tasks.
1.3 Operation and handling requirements of **tools**, equipment and **materials**.

**Range:**
**Tools** - screwdriver, hammer, chisel, grip, wrench, spanner, spirit level, manual pipe threader, pipe cutter, hand saw, plier, bending tool, blow torch

**Materials** - copper pipework/fittings, LCS pipework/fittings, plastic pipework/fittings

**What do learners need to learn?**
Common equipment and materials and their purpose. New and emerging systems, tools and technology used to ensure currency of practice. Additional tools and equipment that can be used for adapted ways of working.

**Skills**

### Heating systems

1.4 **Components** used in heating systems.

**Range:**
**Components** - radiator valves (thermostatic and manual valves), automatic air vents, filling loop, pressure gauge, feed and expansion cisterns, circulating pumps, anti-gravity valves, drain valves, buffers, pressure relief valves, expansion joints, corrosion filters, zone valves (2 port, 3 port, mid position and diverter), low loss headers for multiple boiler installation, programmer, programmable room stat, optimizer, frost stat, cylinder stat, expansion vessel, automatic by-pass, temperature weather compensation, delayed start, optimum start, home automation systems, smart control systems and associated equipment correct connection to home Wi-Fi networks.

**What do learners need to learn?**
Components used in heating systems (e.g. thermostats, valves etc.), their characteristics, effect of type of energy source e.g. oil, solid fuel, function within the system and how they work together to support the operation of the system.

**Skills**

1.5 **Factors** that affect the choice and suitability of components in a heating system.

**Range:**
**Factors** - appliances, purpose, size, location, cost, end users' needs, Building Regulations requirements, local availability

**What do learners need to learn?**
Factors that affect the choice and suitability of components included in a system.

**Skills**

EC5
1.6 **Appliances** supported by heating systems.

**Range:**
**Appliances** - cylinders, heat emitters, fan convectors.

**What do learners need to learn?**
Different types of appliances supported by heating systems including their limitations, operating parameters and legal requirements.

---

1.7 Types of waste and waste products found in different types of heating systems.

**What do learners need to learn?**
Waste and waste products, their attributes (e.g. magnetite, corrosion etc.), hazards to user and interaction with other parties including the consumers.

---

1.8 **Safety devices** applicable to heating systems.

**Range**
**Safety devices** - pressure/temperature relief valve, overheat thermostats, control thermostats.

**What do learners need to learn?**
Safety devices applicable to heating systems, their characteristics and operation.

Skills: MC2

---

**Heating engineering science**

1.9 **Scientific principles** and concepts of heating engineering.

**Range:**
**Scientific principles** -
**Combustion** - complete combustion, incomplete combustion, ventilation, flue draft, combustion triangle.

**Heat transfer** - conduction, convection, radiation, heat loss.

**Processes** - fuels, smouldering, diffusion, rapid, spontaneous.

**What do learners need to learn?**
The application of scientific principles and concepts to heating engineering.

Skills
1.10 Heating Systems and the combustion process.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The combustion process for heating systems. The checks to undertake as part of the combustion process, could include:</td>
<td></td>
</tr>
<tr>
<td>• Combustion analysis</td>
<td></td>
</tr>
<tr>
<td>• Carbon monoxide (CO)</td>
<td></td>
</tr>
<tr>
<td>• Types of burners pre aerated, post aerated</td>
<td></td>
</tr>
<tr>
<td>• Interaction with other devices e.g. ventilators and MVHR</td>
<td></td>
</tr>
</tbody>
</table>

1.11 Flues in relation to gas and the combustion process.

**Range:**
**Flues** - open flued, room sealed

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of flues and the relation to gas and the combustion process. The types of flue, sizes and the correct and safe operation in line with industry requirements.</td>
<td></td>
</tr>
</tbody>
</table>

1.12 Ventilation in relation to gas and the combustion process.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilation in relation to gas and the combustion process including the purpose, types and method of providing ventilation.</td>
<td></td>
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</tbody>
</table>

**Pipework technology**

1.13 Types of **pipework**.

**Range:**
**Pipework** - copper pipework, LCS pipework, plastic pipework

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics of different types of pipework, including prefabricated and modularised components and distribution systems, different sizes, types of materials, their suitability for different situations and tools and equipment (including fixings) required.</td>
<td></td>
</tr>
</tbody>
</table>
1.14 Types of support, fittings and fixings.

Range:
Support - saddle clip, munson ring, plastic clip, LCS bracket, nail in clip, anchor bolts
Fixings - cavity fixings, nails, screws, wall plugs.

**What do learners need to learn?**

Different types of support, fittings and fixings and their suitability for different systems, purposes and building fabrics.

**Skills**

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**Regulations, legislation and industry guidance**

1.15 Implications of legislation and additional guidance to employers and those working with heating systems.

Range:

**What do learners need to learn?**

Implications of legislation and additional guidance to employers and those working with heating systems including legal requirements and the consequences of not following the legislation.

**Skills**

EC5
Specific knowledge criteria for performance outcomes

System installation (PO2)

1.16 Bending techniques.

Range:
Bending techniques - machine bending, scissor, hand (spring bend).

What do learners need to learn?  
Different types of bending techniques and when they would be used. The equipment used to carry out accurate bending of low carbon steel and copper.

1.17 Connection techniques.

Range:
Connection techniques - solder ring and end feed, compression, push-fit, press-fit, threaded.

What do learners need to learn?  
Different types of connection techniques used during the installation and maintenance of heating systems and where and when to use them.

System commissioning (PO3)

1.18 Inspection techniques.

Range:
Inspection techniques - visual inspection, flu gas analyser, differential thermometer.

What do learners need to learn?  
Inspection techniques and how they are applied during the commissioning of heating systems in conjunction with manufacturer’s instructions and current industry guidance.

Skills EC5
1.19 **Factors** to inspect during commissioning.

**Range:**
**Factors** - temperature of emitters, flow and return temperature, flow rate, pressure.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factors to inspect during commissioning and how expected standards are defined in conjunction with manufacturer’s instructions and industry guidance.</td>
<td>MC2 MC6</td>
</tr>
</tbody>
</table>

1.20 **Testing techniques** and their application.

**Range:**
**Testing techniques** - soundness testing, safety component testing, performance testing

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The process for carrying out testing including the type of test required for the system and the test pressures/durations in line with the relevant current British Standards.</td>
<td>MC2 EC5</td>
</tr>
</tbody>
</table>

**System maintenance (PO4)**

1.21 **Fault finding techniques** and their application.

**Range:**
**Fault finding techniques** - end user, manufacturer instructions, fault diagnosis flow charts, service history, industry experience

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fault finding techniques on system components through visual inspection of system, operational checks and performance testing to gather information to be used as part of analysis of situation.</td>
<td>EC5 MC2 DC1 DC5</td>
</tr>
</tbody>
</table>
1.22 **Causes** of typical faults in heating systems.

**Range:**
**Typical faults** - pumping over, persistent venting, emitter cold spots, stuck TRVs, motorised valves not operating, heat when no demand, leaks, blockages, pump failure, control failure
**Causes** - poor installation, inadequate design, user error, environmental factors

**What do learners need to learn?**
Common heating faults and how they are caused during normal operation of a heating system. Causes to include:

- Poor installation
- Inadequate design
- User error
- Environmental factors

Skills
- MC2

1.23 Actions required when faults cannot be rectified.

**What do learners need to learn?**
The actions required when faults cannot be rectified and the potential implications to customer and business including:

- time
- costs
- loss or temporary loss of industry operations
- alternative provisions

Skills
- MC2
- MC10
- EC1
- EC6

**System decommissioning (PO5)**

1.24 **Procedures** involved in decommissioning.

**Range:**
**Procedures** - notify relevant person, isolation of the fuel/electricity supply to the system as appropriate, isolate water supply, apply warning notices and signs, drain system to a suitable location, appropriately dispose of contents and any additives, continuity bonding as required, temporary capping of pipework sections as required, notify building users, alternative supplies as required

**What do learners need to learn?**
Step by step procedure for decommissioning heating systems, including safe isolation, the application of warning notices and notification to the relevant person.

Skills
- MC2
- MC10
- EC1
- EC6
1.25 Requirements for recording, labelling and reporting decommissioned systems.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements for each system to record, label and report decommissioned systems to prevent the use of decommissioned appliance to include:</td>
<td></td>
</tr>
<tr>
<td>• Informing the responsible person</td>
<td>EC1</td>
</tr>
<tr>
<td>• Warning notices</td>
<td>EC3</td>
</tr>
<tr>
<td>• Labels</td>
<td>EC4</td>
</tr>
<tr>
<td></td>
<td>EC6</td>
</tr>
</tbody>
</table>
Performance outcome 2 - Install heating systems

2.1 Install **pipework** relevant to the type of system.

**Range:**
**Pipework** - copper pipework, LCS pipework, plastic pipework.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install pipework relevant to the type of system to be worked on with consideration of measuring and recording accurately in line with industry and practices. Pipework installed must be completed in line with Building Regulations, industry standards and best practices.</td>
<td>MC1</td>
</tr>
</tbody>
</table>

2.2 Install **clips/brackets** to different types of **building fabric**.

**Range:**
**Clips/brackets** - saddle clip, munson ring, plastic clip, LCS bracket, nail in clip, munson rings, school board clips.

**Building fabric** - timber, masonry, plasterboard.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install and fix pipework clips and brackets at recommended spacing intervals to meet specification requirements and in line with current industry standards.</td>
<td>MC1</td>
</tr>
</tbody>
</table>

2.3 Install **flues/chimneys**.

**Range:**
**Flues/chimneys** - fan assisted, condensing flues, plastic flue pipe systems.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position, install and secure flues/chimneys in line with specification requirements and current industry standards/working methods, following manufacturer’s instructions.</td>
<td>MC1</td>
</tr>
</tbody>
</table>
2.4 Install **ventilators**.

**Range:**
**Ventilators** - grilles, vents

**What do learners need to learn?**
Install ventilators in line with specification requirements taking into consideration the type of vent and its suitability. (Hit and miss, fly screen, size).

**Skills**
MC1

2.5 Install **appliances**.

**Range:**
**Appliances** - boilers, fires.

**What do learners need to learn?**
Position, install and secure appliances in line with specification requirements and current industry standards/working methods, following manufacturer’s instructions.

**Skills**
MC1

2.6 Install **heat emitting devices**.

**Range:**
**Heat emitting devices** - traditional radiators, underfloor heating components.

**What do learners need to learn?**
Install a heat emitting device with consideration of appropriate fixing for material, installation equipment and safety requirements during installation.

**Skills**

2.7 Install **components** into appliances.

**Range:**
**Components** - diverter valves, safety controls, automatic air vents, circulating pumps, PCBs.

**What do learners need to learn?**
Install components listed in the range into pre-installed appliances in line with manufactures instructions.

**Skills**

2.8 Install **controls** into a range of systems.

**Range:**

**Controls** - timing devices – clocks and programmers, room thermostats, hot water thermostats, smart controls, zone valves, automatic bypass valves.

**What do learners need to learn?**

Install components listed in the range into a range of systems in line with manufactures instructions.

**Skills**

DC6

---

2.9 Install **thermal insulation materials**.

**Range:**

**Thermal insulation materials** - polyisocyanurate foam, PVC foam, polyethylene foam

**What do learners need to learn?**

Install thermal installation materials taking into consideration the material and suitability.

**Skills**

---

2.10 Install seals for heat emitting devices.

**What do learners need to learn?**

Install seals for heat emitting devices in line with manufactures instructions including PTFE on radiator tails, rubber seals, vent points and blanks on a radiator.

**Skills**

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2.11 Check **heating products** are in accordance with design parameters.

**Range:**

**Heating products** - radiator sizes, boiler size, zone valves, controls, pressure vessels, feed and expansion cisterns, circulating pumps.

**What do learners need to learn?**

Carry out the following checks in heating products to ensure they meet system design parameters:

- temperature
- flow rate
- pressure.
- electrical controls
- mechanical controls
- functional testing.

**Skills**

MC1
MC2
EC5
2.12 Install control systems for the **system**.

**Range:**
**System** - fully pumped, 3 x 2 port valves (S plan Plus)

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
<th><strong>Skills</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Install control systems for heating systems in line with manufactures instructions and current Building Regulations and British Standards.</td>
<td>EC5</td>
</tr>
</tbody>
</table>

2.13 Prepare a safe working environment to conduct heating system installation.

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
<th><strong>Skills</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare a safe working environment to conduct heating system installation by clearing the work area, ensuring correct storage of materials and equipment in line with industry practices referring to health and safety documentation:</td>
<td>EC5</td>
</tr>
<tr>
<td>• risk assessment</td>
<td></td>
</tr>
<tr>
<td>• method statement</td>
<td></td>
</tr>
<tr>
<td>• clear working area</td>
<td></td>
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<tr>
<td>• site survey</td>
<td></td>
</tr>
</tbody>
</table>

2.14 Update line diagrams/installation plans.

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
<th><strong>Skills</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Update line diagrams/installation plans following heating installation. There is no requirement to create an installation plan/system plan within the system, updating of basic data as part of planning review is all that is required.</td>
<td>MC1, MC2, MC6, EC1, EC2, EC3, DC5</td>
</tr>
</tbody>
</table>
2.15 Use **hand and power tools** when penetrating a range of building fabrics.

**Range:**

**Hand and power tools** - power drill, hand saw, hammer, wood chisel.

**What do learners need to learn?**

Use hand and power tools listed in the range to penetrate a range of building fabrics following safe systems of work (visual checks to ensure safe for use, PAT tested as appropriate, used in line with training and only where trained to do so).

**Skills**

DC1
DC2
DC3
DC5
DC6

2.16 Update digital building information management system software.

**What do learners need to learn?**

Update basic information within a digital building information management system following heating installation. There is no requirement to create an installation plan/system plan within the system, updating of basic data as part of planning review is all that is required.

**Skills**

DC1
DC2
DC3
DC5
DC6
**Performance outcome 3 - Commission heating systems**

3.1 Assess risks associated with completing activities.

**What do learners need to learn?**

Produce a risk assessment for commissioning activities in accordance with the five stages of assessment:

- Identification of hazards
- Identification of who is at risk and how
- Assessment of risk and action
- Recording of findings
- Review of risk assessment
- Take appropriate safety precautions

Record risk assessment findings in line with regulations as well as responsibilities of employee’s vs employers.

**Skills**

| EC1 |
| EC2 |
| EC3 |
| EC4 |

3.2 Set **heating controls**

**Range:**

**Heating controls** - programmer, time clock, thermostats, programmable room stat, optimizer, smart controls.

**What do learners need to learn?**

Set the heating controls and parameters in accordance with manufacturer’s technical instructions and end user requirements.

**Skills**

| EC5 |

3.3 Verify fitness for purpose of **tools/equipment**.

**Range:**

**Tools/equipment** - thermometer, voltage indicating device.

**What do learners need to learn?**

Verify fitness for purpose of tools/equipment using a known source.

**Skills**

| EC5 |
3.4 Complete heating system **handover documentation**.

**Range:**
**Handover documentation** - benchmark logbook, handover pack- instructions, user guide, warranty information.

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete heating system handover documentation and pass to the end user. Explain details of this pack and provide full demonstration of all controls and equipment.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Skills</strong></th>
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</thead>
<tbody>
<tr>
<td>EC1</td>
</tr>
<tr>
<td>EC2</td>
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<tr>
<td>EC3</td>
</tr>
<tr>
<td>EC4</td>
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<tr>
<td>EC6</td>
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</tbody>
</table>

3.5 **Test** heating system installation.

**Range:**
**Test** - temperature, flow rate, pressure

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
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</thead>
<tbody>
<tr>
<td>Perform appropriate soundness tests, in line with current industry requirements, on installed systems and components, with consideration of materials used and testing method. Ensure tests conforms to original design requirements.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Skills</strong></th>
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</thead>
<tbody>
<tr>
<td>MC1</td>
</tr>
<tr>
<td>MC2</td>
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<tr>
<td>EC5</td>
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</table>

3.6 Adjust heating system parameters to commission.

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjust heating system parameters to commission in accordance with manufacturer’s instructions.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Skills</strong></th>
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</thead>
<tbody>
<tr>
<td>EC5</td>
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</table>

3.7 Test heating system.

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Carry out the operational checks required during commissioning. Test system to include fully pumped, 3 x two port valves (S plan+)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Skills</strong></th>
</tr>
</thead>
</table>
3.8 Record **commissioning results**.

**Range:**

**Commissioning results** - temperature, flow rate, pressure.

**What do learners need to learn?**

Complete system commissioning records to industry standards with the required information outlining the actions that must be taken when commissioning reveals defects.

**Skills**

EC3

EC4

3.9 Visually inspect correct equipment is utilised in the heating system.

**What do learners need to learn?**

Visually inspect correct equipment is utilised in the heating system with reference to original specifications and diagrams.

**Skills**

3.10 Compare commissioning results against design parameters.

**What do learners need to learn?**

Compare commissioning results against design parameters to determine correct installation in accordance with original design ensuring efficiency and compliance to manufactures instructions.

**Skills**
Performance outcome 4 - Maintain heating systems

4.1 Identify any end user concerns around system operation.

What do learners need to learn?
Use open questioning and listening to discuss maintenance requirements with end user/client with reference to other relevant available source materials – e.g. manufacturer’s instructions/service history documents.

Advising on options for system/component maintenance and how it can best be achieved. Consideration should be made to potential barriers/concerns, how to overcome them as well as to reference of costs, sustainability and timescales.

Skills
EC1
EC2
EC3
EC4
EC5
EC6
MC2
MC6

4.2 Calculate maintenance downtime prior to deactivating.

What do learners need to learn?
Calculate maintenance downtime prior to deactivating the system. Consideration should be made for information to be passed on to the end user, including the impact on the end user or industrial practice. e.g. hospital.

Skills
MC2
MC10

4.3 Conduct fault finding.

Range:
Fault finding - manufacturer’s instructions, service history, end user

What do learners need to learn?
Complete inspection for potential faults on system components in a methodical manner using a range of techniques including visual inspection of system, operational checks and performance testing to gather information to be used as part of analysis of situation.

Reference may also be made to manufactures instructions or specifications (e.g. fault-finding flow chart).

Skills
MC2
EC5
4.4 Engineer **corrective measures** to rectify fault.

**Range:**  
**Corrective measures** - change a selection of pipework, replace TRV, replace motorised valve, replace heating pump, bleed radiator, remove and replace radiator, check and re-pressurise expansion vessel.

**What do learners need to learn?**  
Carry out the corrective methods for the listed components, safely and in line with manufactures requirements and to meet industry standards. Consideration should be made of cost of repair versus replacement of component(s).

**Skills**  
MC2  
EC5

4.5 Assemble system **components**.

**Range:**  
**Components** - heat emitters, pumps, zone valves, expansion vessel.

**What do learners need to learn?**  
Carry out the assembly of components as required, safely and in line with manufactures requirements and to meet industry standards.

**Skills**

4.6 Disassemble system components when conducting maintenance.

**What do learners need to learn?**  
Disassemble system with safe isolation and strip down of plumbing components following employee and manufactures recognised process – systematically and with regard to minimising disruption and mess.

**Skills**

4.7 Repair faulty heating system **components** as identified.

**Range:**  
**Components** - radiator valves – thermostatic and manual valves, timing devices – clocks and programmers, room thermostats, hot water thermostats, zone valves (2 port, 4 port, mid position and diverter), circulating pumps, filling loop, pressure gauge, expansion vessel.

**What do learners need to learn?**  
Carry out the maintenance and repair of components as required, safely and in line with manufactures requirements and to meet industry standards.
4.8 Classify waste for disposal and recycling.

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<thead>
<tr>
<th>What do learners need to learn?</th>
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</thead>
<tbody>
<tr>
<td>Classify waste for disposal and recycling of in line with site management waste plans and approved disposal methods. Consideration should be made to safe/appropriate disposal of replaced components and ensuring.</td>
</tr>
</tbody>
</table>

Skills
Performance outcome 5 - Decommission heating systems

5.1 Apply control mechanisms from a risk assessment prior to working.

Range:
Control mechanisms - safe disposal of heating system fluids, safe isolation of fuel

What do learners need to learn?
Apply control mechanisms from a risk assessment for the safe disposal of heating system fluids and safe isolation of fuel. Apply control mechanisms to a range of systems including sealed systems and open vented systems.

Skills
EC5

5.2 Communicate with user to establish needs when decommissioning heating.

Range:
Needs - temporary heating requirements, duration, hot water requirements.

What do learners need to learn?
Discuss decommissioning requirements with end user taking into consideration end user needs.

Skills
EC1
EC3
EC4
EC6
DC3
DC5

5.3 Safely electrically isolate the heating system prior to decommissioning.

What do learners need to learn?
Safely isolate the heating system following the recognised safe isolation procedure and using the correct equipment.

Skills

5.4 Extract old heating equipment from installation.

Range:
Heating equipment - boiler, radiators, components

What do learners need to learn?
Remove pre-installed components from a pre-installed heating system using safe working practices.

Skills
5.5 Make good building fabric post system removal.

**What do learners need to learn?**
Use construction materials to make good the building fabric following component or system removal, could include filling holes will plaster, removing waste build materials.

**Skills**

5.6 Reinstate appropriate service post decommissioning.

**Range:**
Service - electricity, water, fuel.

**What do learners need to learn?**
Reinstate appropriate services in the range post decommissioning, ensuring safety for the end user and compliance with industry standards.

**Skills**

5.7 Safe disposal of waste products when decommissioning heating systems.

**Range:**
Safe disposal - licensed waste disposal, waste carriers license, recycling, specialist disposal – asbestos and other forms of hazardous waste.

**What do learners need to learn?**
Safely dispose of waste products when decommissioning heating systems. Use appropriate method of disposal for the type of waste product. Decommission different types of heating systems, could include sealed systems and open vented systems.

**Skills**
Heating

Core content
All aspects of the common core and BSE specific core content can be related and contextualised on delivery in relation to this specialism. However, the following are key areas of the content that may be of particular relevance when delivering the knowledge and practical content for this specialism and may provide efficiencies for teaching core knowledge in context;

Common core content:
- Construction sustainability principles - Energy production and energy use and waste management
- Building technology principles - Internet of things
- Construction information and data principles - Standards, regulations and guidance

BSE specific core content:
- Health and safety - BSE Regulations and safe working practices
- Building Services Engineering (BSE) systems – Heaters, radiators
- Tools and equipment - Use and maintenance

Links to Core Skills
As part of delivery of the skills and knowledge within this specialism reference should be made to criteria that support the development of the four core skills – communication, working collaboratively, problem solving and research. Some examples of criteria that may be linked to supporting these core skills include:

- Communication e.g. providing information and advice to customers and / or wider stakeholders on the potential risks of a change to an industrial system, or making a presentation to a stakeholder on the implications of change.
  Example criteria
  o 3.4 will support a learner’s personal development in how to communicate with others, by explaining handover documentation to end user.

- Work collaboratively with other team members and stakeholders e.g. to develop content to bid for a construction project.
  Example criteria
  o 1.24 will support a learner’s personal development in how to work collaboratively with other trades and end users when decommissioning systems.

- Applying a logical approach to solving problems, identifying issues and proposing solutions e.g. through setting criteria for successful implementation of a system, using cost / benefit analysis of the introduction of new procedures or equipment.
  Example criteria
  o 4.3,4.7 will support a learner’s personal development in how to apply a logical approach to solving problems by identifying issues through inspection, operational checks and performance testing and carrying out any identified maintenance or repair as required.

- Primary research e.g. obtaining measurements related to a design and / or customer requirements.
Example criteria
- 5.2 will support a learner’s personal development in how to research by identifying user needs when decommissioning heating systems.

Guidance for delivery
- Opportunities for efficiencies in delivery
- Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery
- Formative assessment – oral Q&A, SmartScreen worksheets (samples available) observation of measuring activities
  - Practical –Use of pre-set formative assessments carry out tasks and record on standardised form
  - Knowledge – pre-set paper-based activity to confirm skills and understanding.
    Learners can use variety of methods to carry out activities, calculators, apps, office IT

- Ways of ensuring content is delivered in line with current, up to date industry practice
  - Centres will need to ensure a realistic representation of heating systems and components
  - Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
  - The provision must represent the type of equipment currently available in the UK heating industry
  - Staff delivering the qualification should be technically competent and have up to date industry CPD
  - Current and emerging heating technology should be included in delivery e.g. smart controls

Suggested learning resources

Books
- The City & Guilds Textbook: Plumbing Book 2 for the Level 3 Apprenticeship (9189), Level 3 Advanced Technical Diploma (8202) and Level 3 Diploma (6035) (City & Guilds)
- Collins Complete Plumbing and Central Heating (Collins)
- CORGIdirect Commercial Heating Manual - Non Domestic - ND3 (CORGIdirect)
- CORGIdirect Central Heating - Wet and Dry Manual - GID7 (New 5th Edition) (CORGIdirect)

Websites
- Institute for apprenticeships and technical education https://www.instituteforapprenticeships.org/
- WaterSafe https://www.watersafe.org.uk
- National Careers Service https://nationalcareers.service.gov.uk/job-profiles/plumber
- Plumberparts You Tube - https://www.youtube.com/user/plumberparts
- CIPHE - https://www.ciphe.org.uk/
- Honeywell - https://heatingcontrols.honeywellhome.com/
- Grundfos - https://uk.grundfos.com/
- Worcester Bosch- https://www.worcester-bosch.co.uk/
• Baxi - https://www.baxi.co.uk
• Danfoss - https://www.danfoss.com/en-gb/
What is this specialism about?
The purpose of this specialism is for learners to learn about and undertake fundamental plumbing work. Learners will have the opportunity to plan, perform and evaluate their work whilst using a range of materials, methods and techniques.

Learners will develop their knowledge, understanding and skills of:

- Fundamental Health & Safety practices associated with carrying out plumbing work.
- Plumbing tools and equipment
- Pipework materials, installation methods and jointing processes.
- Plumbing systems and their purpose
- Plumbing science
- Principles of measurement and marking out components and pipework

Learners may be introduced to this specialism by asking themselves questions such as:

- What kind of tasks does a plumber perform?
- What systems do plumber’s work on?
- What tools and equipment do plumber’s use as part of their role?

Underpinning knowledge outcomes
On completion of this specialism, learners will understand:
1. Plumbing knowledge criteria

Performance outcomes
On completion of this specialism, learners will be able to:
2. Install plumbing systems
3. Commission plumbing systems
4. Maintain plumbing systems
5. Decommission plumbing systems

Completion of this specialism will give learners the opportunity to develop their Maths, English and Digital Skills. Details are presented at the end of the specification.
Specialism content

Common knowledge criteria

Health and safety
1.1 Key requirements of Codes of Practice (CoP).

Range:

What do learners need to learn?
Current legislation/regulation and who is responsible for safety under relevant legislation and codes of practice. The potential implications of non-compliance.

Skills EC5

1.2 Typical hazards and risks associated with plumbing systems.

Range:
Typical hazards - tripping hazards, slipping hazards, inadequate or lack of personal protective equipment, defective (unsafe) equipment, manual handling, working at heights, electrocution.

What do learners need to learn?
Common hazards across all types of systems as well as specifics relating to the different stages of plumbing activities – Commissioning, installation, maintenance and decommissioning.
The controls that need to be in place to minimise hazards.

Skills
Tools, equipment and materials
1.3 Tools, equipment and materials used for installation.

Range:
Tools – screwdriver, hammer, chisel, grip, wrench, spanner, spirit level, manual pipe threader, pipe cutter, hand saw, plier, bending tool, soldering equipment, pressfit.


What do learners need to learn?\[ Skills\]
Common equipment and materials and their purpose. New and emerging systems, tools and technology used to ensure currency of practice. Additional tools and equipment that can be used for adapted ways of working.

1.4 Operation and handling requirements for tools and equipment.

What do learners need to learn?\[ Skills\]
The use of electricity for powered tools and the specific safety considerations relating to their use and hazards. Maintenance schedules and processes for escalating or reporting broken, unsafe or faulty equipment. PAT test requirements, PPE requirements.

Plumbing systems
1.5 Plumbing systems.

Range:
Plumbing systems - above ground drainage, below ground drainage, rainwater harvesting, rainwater systems, grey water re-use, hot water, cold water

What do learners need to learn?\[ Skills\]
Main types of systems, including variations, their purpose and key considerations for installation and maintenance.
1.6 **Components** used in plumbing systems.

**Range:**
*Components* - WC flushing cistern, sink tap, terminal fittings, bath, drain valves, blending valves, check valves, air admittance valves, float operated valves, service valves, supply stop valves, WC, basin, appliance trap, flushing syphons

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
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<tbody>
<tr>
<td>Components used in plumbing systems, their characteristics and function within the system and how they work together to support the operation of the system.</td>
</tr>
</tbody>
</table>

| Skills | EC5 |

1.7 **Factors** that affect the choice and suitability of components in a system.

**Range:**
*Factors* - appliances, purpose, size, location, temperature, flow rate, pressure, environmental, customer needs.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
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<tbody>
<tr>
<td>Factors that affect the choice and suitability of components included in a system.</td>
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</table>

| Skills | EC5 |

1.8 Types of **control systems** required for plumbing systems.

**Range:**
*Control systems* - digital water controls, solenoid valves, infrared controls, water treatment

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
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<tbody>
<tr>
<td>Types of control systems required for plumbing systems including digital controls, their characteristics, operation and suitability for different situations.</td>
</tr>
</tbody>
</table>

| Skills | |

1.9 **Appliances** supported by plumbing systems.

**Range:**
*Appliances* - WC, basin, bath, shower, urinal

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
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<tbody>
<tr>
<td>Common appliances connected to plumbing systems; their limitations, operating parameters, waste outputs and fluid categories.</td>
</tr>
</tbody>
</table>

| Skills | |
1.10 Types of waste and waste products and the associated systems and attributes.

**Range:**
Systems - septic tanks, wastewater lifters, macerators
Attributes - smells, bacteria

**What do learners need to learn?**
Main types of waste and waste products including types of systems. The hazards to user and interaction with other parties including the undertaker and treatment.

**Skills**

1.11 The effects of damage interference from external sources on system operation.

**Range:**
External sources - electrolytic action, atmospheric corrosion, chemical damage, water damage, heat damage, mechanical damage, UV damage, freezing, cold, vibration.

**What do learners need to learn?**
Potential effects of damage interference from external sources on system operation.

**Skills**

**Plumbing science**
1.12 Scientific principles and concepts to plumbing engineering.

**Range:**
Scientific principles - types of water, properties of water, chemical states, sources and storage, water quality, water treatments, behaviour under different temperatures.

**What do learners need to learn?**
Scientific principles, their applications, interaction between them to meet the purpose of the system and how their performance in the system is measured.

**Skills**

1.13 Relationship between flow and pressure.

**What do learners need to learn?**
Relationship between flow and pressure for both liquids and gas to include Boyle’s Law and Charles’s Law.

**Skills**
1.14 Relationship between mass/volume and specific heat capacity.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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<tbody>
<tr>
<td>How to calculate specific heat capacity.</td>
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1.15 Types of **insulation materials**.

**Range:**

**Insulation materials** - polyisocyanurate foam, PVC foam, polyethylene foam.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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<tbody>
<tr>
<td>Types of insulation materials, their properties including relevant standards and current Building Regulations and their suitability for different systems.</td>
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</table>

1.16 Electrolyte qualities of materials and the periodic table.

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<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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<tbody>
<tr>
<td>Electrolyte qualities of materials – the type, installation and size of pipework and fittings and their effect on flow rates.</td>
<td></td>
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</table>

**Pipework technology**

1.17 Characteristics of types of **pipework**.

**Range:**

**Pipework** - prefabricated components, modularised components, on-site installation.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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<tbody>
<tr>
<td>Characteristics of different types of pipework including prefabricated and modularised components and distribution systems, different sizes, types of materials, their suitability for different situations and tools and equipment (including fixings) required.</td>
<td></td>
</tr>
</tbody>
</table>
1.18 Types of **support**, fittings and **fixings**.

**Range:**
**Support** - saddle clip, munson ring, plastic clip, LCS bracket, waste pipe clip, soil pipe clip, nail in clip, gutter and rainwater clips.

**Fixings** - cavity fixings, nails, screws, wall plug, appliance fixing kit.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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<tbody>
<tr>
<td>Different types of support, fixings and fittings and their purpose and suitability for different systems and building fabrics.</td>
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</table>

**Information and data**
1.19 Plumbing drawing symbols and markings.

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<thead>
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<th>What do learners need to learn?</th>
<th>Skills</th>
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<tbody>
<tr>
<td>Common drawing symbols and markings.</td>
<td>EC3</td>
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1.20 Types of **documentation**.

**Range:**
**Documentation** - commissioning record, maintenance record, delivery note, job specification, working drawings, work programme, plans, quotations and estimates, invoice, risk assessment, method Statement.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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<tbody>
<tr>
<td>Different types of documentation, the specific content of different documents and what they are used for.</td>
<td>EC3 EC5 MC1 MC2</td>
</tr>
</tbody>
</table>

**Measurement**
1.21 Metric and imperial dimensions.

**Range:**
**Metric and imperial dimensions** - Metre (length) m, kilogram (mass) k, feet, inches, centre metre, millimetre, Bar (metric unit of pressure), PSI (pound per square inch, or pound force per square inch).

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
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<tbody>
<tr>
<td>The metric and imperial dimensions of height, weight, length and pressure.</td>
<td>MC1 MC3 MC4</td>
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</table>
### Specific knowledge criteria for performance outcomes

#### System installation (PO2)

**1. Plumbing knowledge criteria**

1.22 **Bending techniques.**

**Range:**

**Bending techniques** - machine bending, scissor, hand (spring bend), pre formed.

**What do learners need to learn?**

Different types of bending techniques and when they would be used. The equipment used to carry out accurate bending of low carbon steel and copper.

<table>
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<th>Skills</th>
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1.23 **Connection techniques.**

**Range:**

**Connection techniques** - solder ring and end feed, compression, push-fit, press-fit, threaded, solvent.

**What do learners need to learn?**

Different types of connection techniques and during the installation and maintenance of plumbing systems and where and when to use them.

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<th>Skills</th>
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1.24 **Potential impact** of installation activities.

**Range:**

**Impact** – no water, temporary loss of water, delayed arrival of resource or materials.

**What do learners need to learn?**

Potential impacts of installation activities on customer essential services and the ways these can be minimised;

- Isolation of services
- Preparation of temporary services – providing water when temporary loss
- Completing work out of hours or when unoccupied – cost related/ disability (no sanitation services)
## System commissioning (PO3)

### 1.25 Inspection techniques.

**Range:**

**Inspection techniques** - visual inspection

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<th>What do learners need to learn?</th>
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<tbody>
<tr>
<td>The use of senses in a visual inspection. The application of visual inspections in commissioning systems and the importance of referring to manufacturer’s instructions.</td>
<td>EC5</td>
</tr>
</tbody>
</table>

### 1.26 Factors to inspect during commissioning.

**Range:**

**Factors** – temperature, flow rate, pressure.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The factors to inspect during commissioning and how expected standards are defined in relation to manufacturer’s guidance and Building Regulations.</td>
<td>MC2, MC6</td>
</tr>
</tbody>
</table>

### 1.27 Testing techniques.

**Range:**

**Testing techniques** - Air testing, hydraulic pressure testing, safety component operation, soundness testing, performance testing.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The different testing techniques when they are used and how they are applied in line with current industry standards. How to carry testing and disposal of bi products safely.</td>
<td>MC2, EC5</td>
</tr>
</tbody>
</table>
1.28 **Documentation** required for commissioning and verification of commissioning.

**Range:**

**Documentation** - commissioning record, service sheet, warranty information, manufacturer’s guarantees, self-certification

**What do learners need to learn?**

The different documentation required for commissioning and verification of commissioning, their content and when and how they are used within the commissioning process.

1.29 **Technical information** required for use by different **stakeholders**.

**Range:**

**Technical information** - Handover Pack, instructions, user guides, service requirements

**Stakeholders** – client/customer, installer, tenant, end user

**What do learners need to learn?**

The types of technical information and different stakeholders. Completion of technical information and who to pass it onto once complete.

**System maintenance (PO4)**

1.30 **Fault finding techniques**.

**Range:**

**Fault finding techniques** – end user, manufacturer’s instructions, fault diagnosis flow chart, service history, industry experience.

**What do learners need to learn?**

Different fault-finding techniques and their application for different situations.
1.31 **Causes** of typical faults in plumbing.

**Range:**
**Causes** - poor installation, inadequate design, user error, environmental factors

**Typical faults** - leak in the system pipework, noise in systems, corrosion of system components, inadequate supply pressure at discharge points, loose pipework, trap seal loss, blockages in system components/pipework.

### What do learners need to learn?

<table>
<thead>
<tr>
<th>Common faults in plumbing systems and how they are caused during normal operation of a plumbing system.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skills</strong></td>
</tr>
</tbody>
</table>

1.32 **Documentation** required for maintenance and verification of maintenance activities.

**Range:**
**Documentation** - manufacturer’s instructions, maintenance record, maintenance program, maintenance checklist, service history, job sheets.

### What do learners need to learn?

<table>
<thead>
<tr>
<th>The different documentation that is required for maintenance and verification of maintenance activities. Know what information is required for each, how they are completed and when they are used.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skills</strong></td>
</tr>
</tbody>
</table>

1.33 **Actions** required when faults cannot be rectified.

**Range:**
**Actions** - notify end user, make appliance safe, apply warning notices/signs, discuss next steps.

### What do learners need to learn?

<table>
<thead>
<tr>
<th>The actions required when faults cannot be rectified and the potential implications to customer and business, including: time, costs, loss or temporary loss of industry operations and alternative provisions.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skills</strong></td>
</tr>
</tbody>
</table>
### System decommissioning (PO5)

1.34 **Procedures** involved in decommissioning **systems**.

**Range:**

**Procedures** - notify relevant person, isolation of the fuel/electricity supply to the system as appropriate, isolate water supply, apply warning notices and signs, drain system to a suitable location, appropriately dispose of contents and any additives, continuity bonding as required, temporary capping of pipework sections as required, notify building users, alternative supplies as required.

**Systems** - Above ground drainage, below ground drainage, rainwater harvesting, grey water re-use, rainwater systems, hot water, cold water.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The decommissioning procedures and your own role and responsibilities.</td>
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</tr>
</tbody>
</table>

1.35 **Waste management procedures**.

**Range:**

**Waste management procedures** - licensed waste disposal, waste carriers license, recycling, specialist disposal, transport of licenced waste.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste management procedures and your own role and responsibilities. Relevant procedure for type of waste. Materials that can be recycled e.g. metals, plastics, wood/cardboard.</td>
<td></td>
</tr>
</tbody>
</table>

1.36 Safe removal of different **types of waste** from the working area.

**Range:**

**Types of waste** - asbestos materials, contaminated water, recyclable, non-recyclable.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods used to safely remove different types of waste from the working area for both licensed and unlicensed disposal.</td>
<td></td>
</tr>
</tbody>
</table>
1.37 **Documentation** required for decommissioning and verification of **decommissioning activities**.

**Range:**

Documentation - job sheet, decommissioning record sheet.  
Decommissioning activities - domestic installations, industrial and commercial installations.

**What do learners need to learn?**

Documentation required for decommissioning and verification of decommissioning activities, their content and purpose.

<table>
<thead>
<tr>
<th>Skills</th>
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</thead>
<tbody>
<tr>
<td>EC1</td>
</tr>
<tr>
<td>EC3</td>
</tr>
<tr>
<td>EC4</td>
</tr>
<tr>
<td>EC5</td>
</tr>
</tbody>
</table>

1.38 Requirements for recording, labelling and reporting decommissioned systems.

**What do learners need to learn?**

Requirements for recording, labelling and reporting decommissioned systems to prevent the use of decommissioned appliances, by: informing the responsible person, warning notices, labels, notify other trades.

<table>
<thead>
<tr>
<th>Skills</th>
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</thead>
<tbody>
<tr>
<td>EC1</td>
</tr>
<tr>
<td>EC6</td>
</tr>
</tbody>
</table>
Performance outcome 2 - Install plumbing systems

2.1 Interpret risk assessments.

**What do learners need to learn?**

Review and interpret risk assessments following HSE Guidance. Consideration of employees vs employees' responsibilities in relation to risk assessment completion. The related documentation:

- Work permit
- Method statement
- Tool box talks

**Skills**

EC4
EC5

2.2 Select **tools**, equipment and **materials**.

**Range:**

**Tools** – screwdriver, hammer, chisel, grip, wrench, spanner, spirit level, manual pipe threader, pipe cutter, hand saw, plier, bending tool, blow torch

**Materials** - copper pipework/fittings, LCS pipework/fittings, plastic pipework/fittings

**What do learners need to learn?**

Select the correct hand and power tools required to complete work activities on plumbing systems, taking into consideration the safe use of the equipment and suitability of tools and equipment matched to specific task.

**Skills**


2.3 Measure site requirements and materials.

**What do learners need to learn?**

Measure site requirements and calculate material requirements from plans/drawings.

Measure fixings to pipework and plumbing components using appropriate available equipment e.g. tape measure, laser measure.

Record findings accurately using appropriate SI units for scale of task, in line with industry standards and practices.

**Skills**

MC1
MC2
2.4 Mark out **requirement**.

**Range:**
**Requirement** - notching timber floor joists, drilling holes – timber floor joists, pipework clipping distances.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare the building fabric for the installation of pipework and plumbing components in line with Building Regulations and industry standards.</td>
<td>MC1 EC5</td>
</tr>
</tbody>
</table>

2.5 Use hand and power **tools**.

**Range:**
**Tools** - power drill, hand saw, hydraulic machine bender, hydraulic crimping kit

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use hand and power tools to secure and install plumbing pipework and appliances following safe systems of work (visual checks to ensure safe for use, PAT tested as appropriate, used in line with training and only where trained to do so).</td>
<td></td>
</tr>
</tbody>
</table>

2.6 Prefabricate pipes by bending to **shape**.

**Range:**
**Shape** - 90° angle, offset angle, passover

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
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</thead>
<tbody>
<tr>
<td>Bend pipes to meet the needs of the pipework specification, use appropriate material (copper, low carbon steel, plastic) and specific site considerations. Use appropriate bending equipment/bending machine, safely and in line with manufactures instructions.</td>
<td></td>
</tr>
</tbody>
</table>
2.7 Cut pipes.

Range
Pipes - copper pipework, LCS pipework, plastic pipework

What do learners need to learn?

Measure and cut pipework materials to required length as detailed in the job specification.

Use appropriate cutting equipment with consideration of safety, materials and equipment available.

Consider site restrictions, such as space and potential mess when cutting ensuring burrs are removed and edges are chamfered.

Skills MC1

2.8 Connect materials using jointing methods.

Range:
Jointing methods -
  - Copper pipe, solder ring and end feed, compression (type A and B), push-fit, press-fit,
  - Low carbon steel (LCS) pipe, threaded
  - Plastic pipe (hot, cold and heating), push fit, compression, proprietary – copper and MDPE
  - Plastic jointing (sanitary) ring seal, compression

What do learners need to learn?

Connect pipework together using the appropriate jointing method for materials, equipment and safety requirements.

Skills MC1

2.9 Fix pipework to structures.

Range:
Pipework - copper pipework, LCS pipework, plastic pipework
Structures – timber, masonry

What do learners need to learn?

Fix pipework clips and brackets at recommended spacing intervals to meet specification requirements and in line with current industry standards.

Skills MC1
2.10 Position and secure **components** in plumbing system.

**Range:**

**Components** - WC flushing cistern, sink tap, wash hand basin tap, drain valves, float operated valves, service valves, supply stop valves, WC, basin, bath, appliance trap.

**What do learners need to learn?**

Position and secure components in line with specification requirements and current industry standards/working methods. Work to be carried out in line with Building Regulations, manufactures instructions and British Standards. Use appropriate fixings to ensure security of components and check to ensure components are level and secure following positioning.

**Skills**

MC1

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2.11 Interpret **information** provided.

**Range:**

**Information** - plans/drawings, job specifications, work programmes, installation instructions, local site considerations.

**What do learners need to learn?**

Use the information provided to install plumbing systems. Collate and review information to inform subsequent installation process. Use information in the creation of a plan, quote or take off.

**Skills**

EC5

---

2.12 Update digital building information management system software.

**What do learners need to learn?**

Update basic information within a digital building information management system following plumbing installation. There is no requirement to create an installation plan/system plan within the system, updating of basic data as part of planning review is all that is required.

**Skills**

DC1

DC2

DC3

DC5

DC6
### Performance outcome 3 - Commission plumbing systems

3.1 Assess risks associated with completing activities.

**What do learners need to learn?**

Produce a risk assessment for commissioning activities in accordance with the five stages of assessment;
- Identification of hazards
- Identification of who is at risk and how
- Assessment of risk and action
- Recording of findings
- Review of risk assessment

Record risk assessment findings in line with regulations as well as responsibilities of employee's vs employers.

**Skills**
- EC1
- EC2
- EC3
- EC4

3.2 Interpret information and data.

**What do learners need to learn?**

Interpret data from visual and other sources including manufacturer’s instructions, Building Regulations, drawings, BS - EN standards, in order to correctly carry out the commissioning process.

As part of this the importance of reference to accurate/current sources should also be made currency of standards and guidance documents, and whether they are subject to change.

**Skills**
- EC5
- MC6

3.3 Inspect the installation of components.

**What do learners need to learn?**

Carry out visual inspection of systems, interpret relevant information sources required to complete commissioning activities in line with manufacturer’s instructions and installation drawings. Escalate any potential issues that have been identified.

**Skills**
- MC2
- EC3
- EC4
- EC5
3.4 Test **systems**.

**Range:**
**Systems** - cold water, hot water, above ground drainage

**What do learners need to learn?**
Perform appropriate soundness tests, in line with current industry requirements, on installed systems and components, with consideration of materials used and testing method.

---

3.5 Ensure accuracy and compliance with intended outcomes.

**Range:**
**Intended outcomes** – temperature, flow rate, pressure, electrical controls, mechanical controls, functional testing.

**What do learners need to learn?**
Carry out operational checks required during commissioning

**Commissioning procedure:**
- visual inspection
- fill and vent
- soundness test
- flush
- operational checks
- commissioning documentation
- handover procedure

---

3.6 Record data from commissioning **checks**.

**Range:**
**Checks** – temperature, flow rate, pressure, operation of controls, functional checks.

**What do learners need to learn?**
Measure and record system information using recognised methods in line with the requirements of current Building Regulations.
3.7 Complete required **documentation**.

**Range:**
**Documentation** - commissioning record, service sheet, benchmark/appliance certificates.

**What do learners need to learn?**
Complete system commissioning records to industry standards with the required information outlining the actions that must be taken when commissioning reveals defects. **Skills**
EC3  
EC4

3.8 Present technical information orally for different stakeholders.

**What do learners need to learn?**
Discuss commissioning requirements with stakeholders during the handover procedure in a professional manner, following employer-set procedures and best practice. Consider audience in terms of delivery method (e.g. in person, over the phone), appropriate use of terminology, appropriate methods of identifying and overcoming barriers as well as the potential implications of miscommunication or communication breakdown. **Skills**
EC1  
EC2  
EC3  
EC4  
EC5  
EC6  
MC2  
MC6
Performance outcome 4 - Maintain plumbing systems

4.1 Identify information **requirements** from a brief.

**Range:**
**Requirements** - end user, manufacturer instruction, fault diagnosis flow chart, service history.

**What do learners need to learn?**

Check all necessary job information is available before commencing the maintenance work with reference to manufactures requirements and guidance.

**Skills**

| EC5 |
| MC2 |
| MC6 |

4.2 Explore end user or client requirements.

**What do learners need to learn?**

Use open question and listening to discuss maintenance requirements with end user or client with reference to other relevant available source materials – e.g. manufacturer’s instructions/service history documents.

Advise on options for system/component maintenance and how it can best be achieved. Consideration should be made to potential barriers/concerns, how to overcome them as well as to reference of costs, sustainability and timescales.

**Skills**

| EC1 |
| EC2 |
| EC3 |
| EC4 |
| EC5 |
| EC6 |
| MC2 |
| MC6 |

4.3 Estimate and calculate time and resources.

**What do learners need to learn?**

Interpret data from sources in order to make judgements for time and resources required for the maintenance process – equipment, materials and manpower etc. Consider potential impacts to the client and the business of inaccurate estimations and calculations.

**Skills**

| MC2 |
| MC6 |
4.4 Analyse situations to identify potential causes for delays and errors.

**What do learners need to learn?**

Identify potential problems in relation to system maintenance procedures as a whole (ie not specific errors with a system) which may affect efficiency and completion e.g. lack of resources, timescale issues, availability of materials/parts, site specific issues, specific client needs etc.

Consider how best to mitigate these potential issues and whether risks can be removed or just minimized.

**Skills**

| MC2 | EC1 | EC6 | DC3 | DC5 |

4.5 Inspect the suitability of materials, **tools and equipment**.

**Range:**

**Tools and equipment** - screwdriver, hammer, chisel, grip, wrench, adjustable spanner/spanner, spirit level, pipe cutter, circlip pliers, plier, plunger, tap reseating tool, drain auger, drain rods, copper pipework/fittings, LCS pipework/fittings, plastic pipework/fittings, pressure gauge, flow cup, thermometer.

**What do learners need to learn?**

Check tools, materials and equipment for suitability via visual inspection or relevant checks, including reporting and removal procedures for faulty or inappropriate items.

**Skills**

| MC2 | EC5 |

4.6 Analyse situations to identify potential faults.

**What do learners need to learn?**

Complete inspection for potential faults on system components through visual inspection of system, operational checks and performance testing to gather information to be used as part of analysis of situation. Refer to manufactures instructions or specifications (i.e. fault-finding flow chart).

**Skills**

| MC2 | EC5 |
4.7 Repair **components** in systems.

**Range:**
**Components** - taps-mixer or pillar, float valve, shower mixer valve, drain valve, WC siphon/drop valve, sanitary appliance trap, line strainer.

**What do learners need to learn?**
Carry out the maintenance and repair of components as required, safely and in line with manufactures requirements and to meet industry standards. Consider cost of repair versus replacement of component(s).

**Skills**

4.8 Disassemble **parts** of a system.

**Range:**
**Parts** - WC flushing cistern, sink tap, wash hand basin tap, shower mixer valve, sanitary appliance trap, hot/cold sanitary pipe work.

**What do learners need to learn?**
System disassembly with safe isolation and strip down of plumbing components following employee and manufactures recognised process – systematically and with regard to minimizing disruption and mess.

**Skills**

4.9 Replace **components** within a system.

**Range:**
**Components** - service valves, supply stop valves, sanitary appliance trap, single/double check valves, gate valves, float operated valves.

**What do learners need to learn?**
Replace components within a system as necessary to meet industry and task specific requirements. Use safe and appropriate methods to dispose of replaced components

**Skills**
Performance outcome 5 - Decommission plumbing systems

5.1 Safely isolate valves/services.

Range:
Valves/services – electrical, water – stop tap, gate valve, sanitary appliances – service valves.

What do learners need to learn?

Procedures for isolation and decommission:
- notify relevant person
- isolate the fuel/electricity supply to the system as appropriate
- isolate water supply
- apply warning notices and signs
- drain system to a suitable location
- appropriately dispose of contents and any additives
- continuity bonding as required
- temporary capping of pipework sections as required
- notify building users
- alternative supplies as required

Decommissioning:
- permanent
- temporary

Skills
EC1
EC2
EC3
EC4
EC5
EC6

5.2 Handle materials to protect their integrity and safety.

Range:
Materials - components, Pipework materials.

What do learners need to learn?

Handle materials to protect their integrity and safety during decommissioning
Adopt safe storage of components and materials following health and safety procedures.

Skills
5.3 Extract **components** from systems.

**Range:**
**Components** - WC flushing cistern, sink tap, wash hand basin tap, bath, drain valves, float operated valves, service valves, supply stop valves, WC, basin, appliance trap

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remove pre-installed components from plumbing systems following recognised industry practices.</td>
<td></td>
</tr>
</tbody>
</table>

5.4 Reconfigure systems.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconfigure plumbing systems during the decommissioning process ensuring the system is left in full working order.</td>
<td></td>
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</tbody>
</table>

5.5 Make good the building fabric.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use construction materials to make good the building fabric following component or system removal.</td>
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</tbody>
</table>

5.6 Categorise **waste**.

**Range:**
**Waste** – licenced, recyclable, specialist, general site.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Categorise the waste produced during the decommissioning process in line with waste management plans and environmental policies. Methods including: Licensed waste disposal, waste carriers license, recycling, specialist disposal – asbestos and other forms of hazardous waste.</td>
<td>EC5</td>
</tr>
</tbody>
</table>
Plumbing

Core content
All aspects of the common core and BSE specific core content can be related and contextualised on delivery in relation to this specialism. However, the following are key areas of the content that may be of particular relevance when delivering the knowledge and practical content for this specialism and may provide efficiencies for teaching core knowledge in context;

Common core content
- Construction sustainability principles - Energy production and energy use and waste management
- Building technology principles - Internet of things
- Construction information and data principles – Standards, regulations and guidance

BSE specific core content
- Health and safety - BSE Regulations and safe working practices
- Building Services Engineering (BSE) systems – Cold water, hot water and sanitation and drainage
- Tools and equipment – Use and maintenance

Links to Core Skills
As part of delivery of the skills and knowledge within this specialism reference should be made to criteria that support the development of the four core skills – communication, working collaboratively, problem solving and research. Some examples of criteria that may be linked to supporting these core skills include;

- Communication e.g. providing information and advice to customers and / or wider stakeholders on the potential risks of a change to an industrial system, or making a presentation to a stakeholder on the implications of change

  Example criteria
  o 3.8/4.2 will support a learner’s personal development in how to communicate with others, by presenting technical information to stakeholders and using open questioning and listening techniques to explore end user requirements

- Work collaboratively with other team members and stakeholders e.g. to develop content to bid for a construction project

  Example criteria
  o 1.33 will support a learner’s personal development in how to work collaboratively with other trades/ end users

- Applying a logical approach to solving problems, identifying issues and proposing solutions e.g. through setting criteria for successful implementation of a system, using cost / benefit analysis of the introduction of new procedures or equipment

  Example criteria
  o 1.30 – 1.33/4.6 will support a learner’s personal development in how to apply a logical approach to solving problems by identifying issues through inspection, testing and fault finding techniques rectifying any identified faults.

- Primary research e.g. obtaining measurements related to a design and / or customer requirements.

  Example criteria
2.3/4.1/4.3 will support a learner’s personal development in how to research by estimating and calculating time and resources to fit identified information requirements from a brief.

Guidance for delivery

- Opportunities for efficiencies in delivery
- Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery
- Formative assessment – oral Q&A, SmartScreen worksheets (samples available)
  - observation of measuring activities
    - Practical - Use of pre-set formative assessments carry out tasks and record on standardised form.
    - Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT
- Ways of ensuring content is delivered in line with current, up to date industry practice
  - Centres will need to ensure a realistic representation of plumbing systems and components are available
  - Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
  - The provision must represent the type of equipment currently available in the UK ventilation industry
  - Current and emerging plumbing technology should be included in delivery where possible

Suggested learning resources

Books

- The City & Guilds Textbook: Plumbing Book 2 for the Level 3 Apprenticeship (9189), Level 3 Advanced Technical Diploma (8202) and Level 3 Diploma (6035) (City & Guilds)
- Collins Complete Plumbing and Central Heating (Collins)
- Plumbing Encyclopaedia 4th edition RD (Treloar)

Websites

- Institute for apprenticeships and technical education https://www.instituteforapprenticeships.org/
- WaterSafe https://www.watersafe.org.uk
- National Careers Service https://nationalcareers.service.gov.uk/job-profiles/plumber
- Plumberparts You Tube - https://www.youtube.com/user/plumberparts
- CIPHE- https://www.ciphe.org.uk/
- Salamandereschool.co.uk
Protection systems engineering

<table>
<thead>
<tr>
<th>Level:</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLH:</td>
<td>440 (tbc)</td>
</tr>
<tr>
<td>Assessment method:</td>
<td>Practical assignment</td>
</tr>
</tbody>
</table>

What is this specialism about?

The purpose of this specialism is for learners to know fundamental protection systems engineering processes and undertake key procedures. Learners will have the opportunity to plan, perform and evaluate their work whilst utilising a range of materials, methods and techniques.

Learners will develop their knowledge and understanding of, and skills in:

- Fundamental health & safety practices associated with carrying out protection systems engineering
- Protection systems and their purpose
- Information and data used in the protection systems industry
- Protection systems installation and commissioning
- Protection systems maintenance and decommissioning

Learners may be introduced to this specialism by asking themselves questions such as:

- What data and details are needed when planning protection system installations?
- What types of checks and adjustments may be required to protection systems after installation?
- Where is system data relating to protection system maintenance recorded?

Underpinning knowledge outcomes

On completion of this specialism, learners will understand:
1. Protection systems engineering knowledge criteria

Performance outcomes

On completion of this specialism, learners will be able to:
2. Install protection systems
3. Commission protection systems
4. Maintain protection systems
5. Decommission protection systems

Completion of this specialism will give learners the opportunity to develop their Maths, English and Digital Skills. Details are presented at the end of the specification.
Specialism content

Common knowledge criteria

Health and safety

1.1 **Safe working practices** specific to work on protection systems.

Range:

**Safe working practices** - carrying out safe isolation before working on systems and equipment, selection of appropriate tools for isolation in accordance with GS 38, discharge / disconnection of stand-by supplies, requirements for working with and disposing of chemical batteries and detectors, requirements for working with fibre optic cables.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe working practices with reference to full, current industry recognised safe isolation procedures.</td>
<td></td>
</tr>
<tr>
<td>Hazards and PPE associated with working with chemical equipment and fiber optic cables.</td>
<td></td>
</tr>
</tbody>
</table>

Tools, equipment and materials

1.2 **Tools** and **equipment** used when working with protection systems.

Range:

**Hand tools** - rules, levels, gauges, plumb lines, cable cutters, screwdrivers, wire strippers, knives, files, wrenches, hammers, saws, data cabling crimps, insulation displacement tools.

**Power tools** - hammer drills, pillar drills, electric screwdrivers

**Equipment** - smoke hoods, smoke cannisters, testing/commissioning equipment, programmers

<table>
<thead>
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</thead>
<tbody>
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<td>Selection of correct hand and power tools and equipment required to complete work activities associated with protection systems, taking into consideration the safe and correct use of the equipment and suitability of tools and equipment matched to specific task, in line with manufacturer's instructions.</td>
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<tr>
<td>Safety checks may include – Check safe to use, correct speed setting, correct attachments, attached correctly, guards in place and use of correct PPE.</td>
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</table>
1.3 Operation and handling requirements of tools and commissioning equipment.

**What do learners need to learn?**
User checks, calibration checks, operation/function of equipment.

**Protection systems**
1.4 Types of protection systems.

**Range:**
Protection systems - fire detection systems (conventional, addressable), security systems (access control, video surveillance and intruder, hold up alarm systems), addressable emergency lighting systems.

**What do learners need to learn?**
Reference to guidance of different types of protection systems used in different building environments. Reference must be consulted with relevant British Standard and manufactures literature. This will range from conventional basic systems to intelligent digital addressable systems at different voltage levels.

The relationship of fire detection and security alarms to the fire and security industry and the requirement and implementation of security risk assessments.

1.5 Protection system components.

**Range:**
Components - heat sensors, smoke sensors, proximity cameras/sensors, control panels, consoles, manual controls, access controls.

**What do learners need to learn?**
Selection and location of components suitable for environment, system and function. Consideration of fire and smoke patterns in and around buildings in relation to fire detection systems.
1.6 Protection system circuits.

Range:
Circuits - open loop, closed loop, addressable, radial, audio/visual circuit, communication, wireless, supply, AC and DC.

What do learners need to learn? | Skills
--- | ---
Circuit properties including suitability, applications, advantages and limitations for given protection system. Effects of series and parallel resistances and configurations. Effects of voltage drop
Specific knowledge criteria for performance outcomes

System installation (PO2)

1.7 Methods of selecting and installing cable installation and wiring support systems.

**Range:**

**Cable installation and wiring support systems** - single and multicore thermoplastic cable, SWA multicore armoured cable, MICC, FP200- Fire resistant cable, data cable Cat5/6, coaxial, cable tray, cable conduit (steel and PVC), cable trunking, ladder racking, cable basket.

**What do learners need to learn?**

How to install cables and containment in line with current legislation and industry practices. When installing cables consideration should be taken of Building Regulations, manufactures instructions and British Standards.

Selection of cable suitable for current capacity, voltage drop limitations and environment.

Selection of wiring support system suitable for environment, type and quantity of cables, and availability of fixing methods.

**Skills**

1.8 Termination of **cables**.

**Range:**

**Cables** - single and multicore thermoplastic cable, SWA multicore armoured cable, MICC, FP200- Fire resistant cable, data cable Cat5/6, coaxial.

**What do learners need to learn?**

Termination and securing of cable glands detailed in the range in line with specification requirements and current industry standards/working methods. When securing terminations consideration should be taken of Building Regulations, manufacturer’s instructions and British Standards.

**Skills**
1.9 Methods of terminating and connecting conductors.

**Range:**
*Terminating and connecting* - screwed, crimped, compression, insulation displacement, clamp.

**What do learners need to learn?**
Termination and connection of conductors as detailed in the range in line with specification requirements and current industry standards/working methods. When securing terminations/connections consideration should be taken of Building Regulations, manufactures instructions and British Standards.

Consideration of advantages and limitations of termination and connection methods and consequences of poor connections.

Shape and type of material being connected, junction of materials and volume/number of conductors.

1.10 Methods of supporting protective system components.

**What do learners need to learn?**
Selection of appropriate fixing methods with consideration of load bearing, environment, building structure/materials and aesthetics.

**System commissioning (PO3)**

1.11 Inspections of protection systems.

**What do learners need to learn?**
Standard procedure and process for how to complete visual inspections as per relevant electrical inspection schedules used in accordance with manufacturers documentation, BS 7671 and IET Guidance Note 3. Consideration should also be given to O&M manuals.
1.12 Testing of protection systems.

**What do learners need to learn?**

Tests to be carried out on protection systems in accordance with manufacturers documentation, BS 7671 and IET Guidance Note 3.

Functional tests and commissioning to manufacturers specifications and system requirements. Identification of incorrect test values and potential implications of incorrect test values.

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1.13 Verification of protection systems.

**What do learners need to learn?**

Verifying compliance with manufacturers standards, GN3 and British Standards, completion of documentation relevant to the protection system and importance of documentation/O&M manual handover to end user.

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**System maintenance (PO4)**

1.14 Types of protection *system maintenance*.

**Range:**

*System maintenance* - planned and preventative maintenance (PPM), reactive.

**What do learners need to learn?**

Legal requirements relating to PPM, responsibilities for undertaking maintenance regimes.

Advantages and limitations of PPM and reactive maintenance. Requirements for completing documentation and updating O&M manuals.
1.15 **Fault finding and rectification techniques.**

**Range:**

**Fault finding techniques** - identification of symptoms, collection and analysis of data, use of sources/types of information (e.g. circuit schedule, installation specifications, drawings/diagrams), determining nature/characteristics of faults through discussion and questioning, checking and testing, analysis of results/information.

**Rectification techniques**

Repair, replace, adjust.

---

**What do learners need to learn?**

Safe working procedures following evaluation and the application of appropriate and logical fault diagnosis methods and techniques. Diagnosis of electrical faults using engineering decision and evaluation of symptoms and findings. Appropriate and efficient action/s that should be recommended to rectify faults.

**Skills**

MC2

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1.16 Maintenance requirements for different building types and locations.

**Range:**

**Building types** - private, commercial, HMO’s, residential.

**What do learners need to learn?**

Regulations concerning set systems to put in place in relation to different types of premises.

Some types of buildings are covered by specific, specialist regulations and control measures e.g. hospitals, chemical plants, paint stores etc.

**Skills**

EC5

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1.17 Maintenance of older systems and installations.

**What do learners need to learn?**

Identification of older systems that may not be compliant with current regulations and reporting on condition and suitability for continued use.

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**Skills**
1.18 Making systems safe to decommission.

What do learners need to learn?

- Isolation of systems from the supply source or outgoing integrated services such as automatic shutters or door releases.
- Handling of materials to protect their integrity and safety during decommissioning. Removal of pre-installed components from protection systems.
- Reconfiguration of protection systems during the decommissioning process. Categorisation of waste produced during the decommissioning process.
- Use of construction materials to make good the building fabric following component or system removal.

Skills

1.19 Methods of identifying potential issues before decommissioning systems.

What do learners need to learn?

Methods including reviewing O&M manuals, consultation of component data sheets and drawings. Benefits of devising a timely plan, when decommissioning systems.

Skills

- MC2
- EC5
Performance outcome 2 - Install protection systems

2.1 Assess risk associated with tasks.

What do learners need to learn?

2.1 Assessment of risk may relate to the production or review of a risk assessment for installation activities, with consideration of specialist equipment required, in accordance with the five stages of assessment:

- Identification of hazards
- Identification of who is at risk and how
- Assessment of risk and action
- Recording of findings
- Review of risk assessment

Risks will vary depending on protection system being installed. Consideration should be made with reference to recording of risk assessment findings in line with regulations as well as responsibilities of employees vs employers.

Skills
EC4
EC5

2.2 Collect and collate information required to complete tasks.

Range:
Information - manufacturer’s instructions, Building Regulations, drawings, BS - EN standards, data sheets.

What do learners need to learn?

Information may include drawings and plans or any relevant information as identified in the range and will relate to the contract/required system.

Review information to ensure its accuracy and validity, including suitability of equipment being installed.

Interpreting data from sources in order to correctly carry out the installation process. As part of this the importance of reference to currency of standards and guidance documents, and whether they are subject to change.

Referring to design specifications and manufacturer data sheet with specific criteria regarding equipment and components required in a system.

Skills
EC4
EC5
2.2 Select tools, equipment and materials to complete tasks.

**What do learners need to learn?**

Selecting the correct materials and hand/power tools or specialist equipment required to complete work activities associated with protection systems, taking into consideration the safe use of the equipment and suitability of tools and equipment.

**Skills**

2.3 Inspect the suitability of plant for use, including tools, materials and equipment.

**What do learners need to learn?**

Inspecting and using hand and power tools safely – using specific tools required to complete different parts of tasks as required. Power tools, plant and equipment checked in accordance with current statutory, non-statutory regulations and codes of practice.

**Skills**

2.5 Analyse formal and informal information to identify potential causes for delays and errors.

**What do learners need to learn?**

Delays and errors may include the work site not being ready, having incorrect drawings, insufficient materials, resources etc.

Learners should review available progress plans such as Gantt charts/critical path analysis tracking, as well as site meetings to discuss progress detailing any causes for concerns.

**Skills**

MC2
MC6
EC4
EC5

2.6 Think creatively to adapt designs appropriately to minimise delays and errors.

**What do learners need to learn?**

Engineering situations to suit different environments and un-planned situations, after consultations with site managers and designers for example where site conditions are different to information provided. This could be through fabrication alterations or cable routes/sizes that require these amendments or alterations once approved need to be formalised on the associated drawings/plans.
2.7 Mark out the position of equipment.

**What do learners need to learn?**

Positioning and securing components for example detection and monitoring equipment locations in line with specification requirements and current industry standards/working methods, smoke patterns and building features/layout. When positioning consideration should be taken of plans/drawings, Building Regulations, manufacturer’s instructions and British Standards.

Considerations given to influences from other installed equipment such as heat producing equipment, steam or external influences such as direct sunlight. Appropriate fixings must be used to ensure security of components and checks should be made to ensure components are level and secure following positioning.

Skills

| MC1 | EC5 |

2.8 Use tools, equipment and materials to carry out tasks.

**Range:**

**Tasks** - installing wiring and containment systems, connecting equipment.

**What do learners need to learn?**

Setting up and using the correct hand and power tools, plant and equipment required to complete work activities on associated protection systems, taking into consideration the safe use of the equipment and suitability of tools and equipment, including suitable PPE, matched to specific tasks.

Skills

| MC1 |

2.9 Install cable containment systems.

**What do learners need to learn?**

Engineering cable and containment installations – to include the measuring and cutting of materials e.g. conduit, trunking, basket and tray etc. to required length as detailed in the job specification. Materials should be cut using appropriate cutting equipment with consideration of safety, materials and equipment available. Consideration should also be made of site restrictions such as space and potential mess when cutting.

Handling materials such as metal and plastic containment systems and different cable types.

When handling, relevant PPE must be worn and selected, as well as the reviewing of material data sheets, where information given must be followed to ensure the safety of the user and correct installation of components.

Skills

| MC1 |
2.10 Install cabling.

What do learners need to learn?
Install cables within containment systems or on support systems using appropriate methods for drawing in, laying and securing. Suitable considerations to protection of cables during installation.

Skills

2.11 Connect equipment to the installed wiring systems.

What do learners need to learn?
Connecting/fixing protection system components together using appropriate methods of fixing as listed in the design specification/manufacturers details e.g. call points, detectors etc. with consideration of material type, materials, and equipment reviewing safety requirements.

Appropriate fixings must be used to ensure security of components and checks should be made to ensure components are level and secure following positioning.

Skills MC1

2.12 Terminate and connect cables and conductors.

What do learners need to learn?
Terminating and securing cable glands e.g. armoured, insulated, coax and data cables etc. and conductors in line with specification requirements and current industry standards/working methods.

When securing terminations consideration should be taken of external influences, Building Regulations, manufacturer’s instructions and British Standards. Appropriate glands and connections/terminations must be used to ensure security of cable types. Checks should be made to ensure termination glands/connections are level and secure.

Skills
Performance outcome 3 - Commission protection systems

3.1 Prepare for inspection, testing and commissioning.

What do learners need to learn?
Gathering the information necessary for detailed inspection, testing and commissioning of protection systems including manufacturers data, design information, tolerances, drawings and charts.

Skills
EC4
EC5

3.2 Inspect protection systems.

What do learners need to learn?
Completing visual inspections as per relevant electrical inspection schedules used in accordance with BS 7671 and IET Guidance Note 3 and other relevant BS Standards and codes of practice. Consideration should also be given to O&M manuals.

Skills

3.3 Test protection systems.

What do learners need to learn?
Tests to be carried out on protection systems in accordance with the BS 7671 and IET Guidance Note 3. Learners must select the appropriate instrument for each test to be carried out in terms of:
- Ensuring the instrument is fit for purpose
- Identifying the correct scale or setting

Skills
MC1
MC2

3.4 Analyse and interpret information and data from ICT applications.

What do learners need to learn?
Interpreting information obtained from digital sources and from testing protection systems. Analysis and interpretation may involve the use of computer programs and packages and reviewing project management literature and plans to ensure compliance of the system.

Why it is necessary for test results to comply with standard values and actions to be taken in the event of unsatisfactory results being obtained.

Skills
MC6
DC1
DC4
DC5
3.5 Adjust protection systems equipment as required by installation standards.

**What do learners need to learn?**

Considering relevant adjustments required in relation to system requirements for example adjusting settings of sensors where required etc. with reference to manufacturers information and design specification for adjustment parameters when altering settings. Also making adjustments with consideration of required standards and requirements.

3.6 Complete **documentation** relevant for tasks.

**Range:**

**Documentation** - Electrical Installation Certificate, Minor Electrical Installation Works Certificate, Schedule of Inspections, Schedule of Test results, Commissioning/Completion certificate

**What do learners need to learn?**

Completing all relevant sections/information that must be contained on initial verification documentation.

Following certification processes for a completed installation, with consideration of the responsibilities of relevant personnel in relation to the completion of the certification process.

Learners must follow requirements for the recording and retention of completed initial verification documentation in accordance with the BS 7671. Completion Certificates and commissioning documentation to be completed in accordance with manufacturer’s specifications and other British Standards applicable to the protection system.

3.7 Use oral and non-verbal communication skills to demonstrate system operation.

**What do learners need to learn?**

With reference to O&M manuals as well as manufacturers information when conveying information on the operation of systems to client and users. Use of techniques to ensure understanding including user demonstration and explanation.
3.8 Update digital building information management system software and/or O&M manuals.

**What do learners need to learn?**

Updating relevant system software may include using different types of program (Word processing, email, spreadsheets etc.), CAD, PLC’s BMS specific software, also information relating to both conventional and addressable systems. Ensuring operational and maintenance manuals are complete and reflect the ‘as fitted’ work undertaken. Information handed over to client and/or users.

**Skills**

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Performance outcome 4 - Maintain protection systems

4.1 Communicate health and safety risks to stakeholders orally.

**What do learners need to learn?**

Communicating with stakeholders in line with system maintenance, for example explaining unsafe situations and the risks associated with them. Communications may relate to the production of a risk assessment for maintenance activities and explaining relevant content of the risk assessment to stakeholders.

**Skills**

| EC1 | EC2 | EC6 |

4.2 Sequence activities required to complete task including planning to isolate electrical supplies and informing relevant people where required.

**What do learners need to learn?**

Following correct sequence of activities to complete a maintenance task:

- Selecting tools/equipment
- Obtaining method statement/work order
- Carrying out safe and secure isolation (including getting permission to isolate)
- Carrying out maintenance activities
- Removing isolation
- Functional testing

**Skills**

| MC1 | MC2 |

4.3 Allocate time and resources to complete the task including materials required.

**What do learners need to learn?**

Reviewing sequence as detailed in 4.2 depth with application of appropriate timings for each stage. Liaison with stakeholders to agree timings to minimise disruption and enhance safety.

**Skills**

| MC6 | DC4 | EC3 |

4.4 Collect system data from ICT applications.

**What do learners need to learn?**

ICT including use of computers, digital transmission over IP, email, mobile communication technology etc for the collection of data and completion of work sheets/maintenance sheets.

**Skills**

| MC6 | DC4 | EC3 |
4.5 Record system data.

**What do learners need to learn?**

System data may include work records or equipment maintenance sheets etc. Familiarity with records of work, including preventative maintenance and reactive maintenance requirements. Inspection and test schedules may be company or system specific, so awareness is needed of documentation required to be completed for maintenance activities.

Skills

EC1
EC3

4.6 Test equipment to ensure it is safe to work on.

**What do learners need to learn?**

Carrying out checks to ensure safe isolation has been carried out correctly and that any stored charge within the equipment has been discharged.

Skills

4.7 Inspect, test and analyse information to identify potential faults.

**What do learners need to learn?**

Inspection for potential faults on system components through visual inspection of system, operational checks, feedback from system users and performance, testing to gather information to be used as part of analysis of situation.

Collating all available information and analysing regarding any possible or potential faults. Reference may also be made to manufacturer’s instructions or specifications (e.g. fault finding flow chart or detailed procedure).

Checking system performance criteria for correct settings, readings or maximum/minimum permitted standards. Analyses of conditions that affect suitability of protective systems such as alterations to building, structure or equipment.
4.8 Think creatively to propose solutions for installation faults.

**What do learners need to learn?**

Using analysis, develop strategic, economic and practical methods for rectifying identified possible or potential faults.

Installation faults and issues may include deteriorating or outdated equipment over time and having contingency plans in place for equipment that is no longer manufactured etc.

Site inventory is required with all equipment details assigned including age. Storage of spare parts is required for equipment and parts of systems that may fail due to a number of reasons.

Contingency budget planning needs to be reviewed regularly with consideration given to performance levels of existing equipment and plant.

Skills
- MC6
- DC4
- MC9

4.9 Communicate written technical advice and guidance to technical and non-technical stakeholders.

**What do learners need to learn?**

Communicate with stakeholders and obtain necessary permissions to rectify faults, prolong potential faults or improve systems for changing conditions.

Conveying information for example safety considerations, system maintenance requirements etc. to inform and educate stakeholders with a specific focus on ensuring all stakeholders are aware of health and safety responsibilities.

Learners must be able to overcome potential barriers to successful communication with specific reference to language and methods used for both technical and non-technical stakeholders.

Skills
- EC1
- EC3
- EC6
- DC3
- DC5

4.10 Replace **components** of protection systems.

**Range:**

**Components** - sensors, detectors, monitoring equipment.

**What do learners need to learn?**

Replacing components within a protection system as necessary to meet industry and task specific requirements. Consideration should be made to safe/appropriate disposal of replaced components and ensuring all work has been recorded or records of work updated including O&M manuals.

Skills
Performance outcome 5 - Decommission protection systems

5.1 Communicate with stakeholders to ensure required information is available to undertake tasks using electronic communication.

**What do learners need to learn?**

Information on systems used in the tracking and monitoring site/contract progress. Communications may include use of software packages (word processing, email, spreadsheets etc.). Information sources may include CAD, PLC’s BMS specific software, also information relating to both conventional and addressable systems.

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5.2 Make systems safe to work on including safe isolation and discharging stored charge.

**What do learners need to learn?**

Carrying out safe isolation procedures and ensuring that the protection system is discharged before commencing work on decommissioning.

5.3 Remove protection systems and maintain records.

**What do learners need to learn?**

Removing all redundant equipment and wiring of the protection system with consideration of categorising waste produced during the decommissioning process.

Using construction materials to make good the building fabric following component or system removal. Updating and changing records to reflect work undertaken.
Protection systems

Core content
All aspects of the common core and BSE specific core content can be related and contextualised on delivery in relation to this specialism. However, the following are key areas of the content that may be of particular relevance when delivering the knowledge and practical content for this specialism and may provide efficiencies for teaching core knowledge in context:

Common core content
- Construction science principles – Electricity, heat
- Construction sustainability principles - Energy production and energy use
- Building technology principles - Internet of things
- Construction information and data principles - Key elements of data

BSE specific core content
- Digital technology in construction - Internet of things, digital engineering techniques, opportunities for the use of technology used in other industries and contexts and adapting for use in construction and the built environment
- Health and safety - BSE Regulations, safe working practices for the safe isolation of systems
- Building Services Engineering (BSE) systems - Electrotechnical principles of components, types of control systems, types of monitoring systems, types of electrical supply, types of earthing arrangements, cable types and sizes, accessories and equipment used in older electrical installations
- Information and data - Drawings, circuit diagrams and schematics, data storage, security and protection, programming and set up of digital systems using IT resources

Links to Core Skills
As part of delivery of the skills and knowledge within this specialism reference should be made to criteria that support the development of the four core skills – communication, working collaboratively, problem solving and research. Some examples of criteria that may be linked to supporting these core skills include;
- Communication e.g. providing information and advice to customers and / or wider stakeholders on the potential risks of a change to an industrial system or making a presentation to a stakeholder on the implications of change.
  Example criteria
    o 3.7 Use oral and non-verbal communication skills to demonstrate system operation.
    o 4.1 Communicate health and safety risks to stakeholders orally.
    o 5.1 Communicate with stakeholders to ensure required information is available to undertake the task using electronic communication.
- Working collaboratively with other team members and stakeholders e.g. to develop content to bid for a construction project.
  Example criteria
    o 4.9 Communicate written technical advice and guidance to technical and non-technical stakeholders.
• Applying a logical approach to solving problems, identifying issues and proposing solutions e.g. through setting criteria for successful implementation of a system, using cost / benefit analysis of the introduction of new procedures or equipment.

**Example criteria**
- 2.5 Analyse formal and informal information to identify potential causes for delays and errors.
- 2.6 Think creatively to adapt designs appropriately to minimise delays and errors.
- 3.4 Analyse and interpret information and data from ICT applications.
- 4.8 Think creatively to propose solutions for installation faults.

• Conducting primary research e.g. obtaining measurements related to a design or customer requirements.

**Example criteria**
- 2.2 Collect and collate information required to complete tasks.
- 2.7 Mark out the position of equipment.
- 4.4 Collect system data from ICT applications.

**Guidance for delivery**

• Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery

• Formative assessment – oral Q&A, SmartScreen worksheets (samples available) observation of measuring activities
  - Practical - Use of pre-set formative assessments to carry out tasks and record on standardised form.
  - Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT

• Ways of ensuring content is delivered in line with current, up to date industry practice
  - Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
  - Teaching coverage must represent the type of equipment currently available and accepted for use in the UK industry
  - Current and emerging electrical installation and testing technologies should be included in the delivery where possible

• Reinforcement of learning – revisiting learning, group discussions, peer support system

**Suggested learning resources**

**Books**
- The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)
  Author: Peter Tanner
  Publisher: Hodder Education (28 Sept. 2018)
• The City & Guilds Textbook: Book 2 Electrical Installations for the Level 3 Apprenticeship (5357), Level 3 Advanced Technical Diploma (8202) & Level 3 Diploma (2365)
  Author: Peter Tanner
  Publisher: Hodder Education (25 Jan. 2019)
• Requirements for Electrical Installations, IET Wiring Regulations, Eighteenth Edition, BS 7671:2018 (Electrical Regulations)
  Author: The Institution of Engineering and Technology
  Publisher: Institution of Engineering and Technology; 18th Edition (2 July 2018)
• Closed Circuit Television
  Author: Joe Cieszynski
  Publisher: Newnes; 3rd edition (28 Dec. 2006)

Websites
• Institute for apprenticeships and technical education
  https://www.instituteforapprenticeships.org/
• National Careers Service https://nationalcareers.service.gov.uk/job-profiles/security-systems-installer
• Electrical Contractors’ Association (ECA) https://www.eca.co.uk/
• Institute of Engineering and Technology (IET) https://electrical.theiet.org/bs-7671/
• Health and Safety Executive https://www.hse.gov.uk/electricity/
• Safety Electrical First- https://www.electricalsafetyfirst.org.uk/
• Electrical Times- https://www.electricaltimes.co.uk/
• Sparks magazine (for trainees)- https://www.sparks-magazine.co.uk/
• Electrical Trade Magazine- https://www.electricaltrademagazine.co.uk/
• Fire & Security matters- https://www.fsmatters.com/Home
**Refrigeration**

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**What is this specialism about?**

The purpose of this specialism is for learners to learn about and undertake fundamental refrigeration work. Learners will have the opportunity to plan, perform and evaluate their work whilst utilising a range of materials, methods and techniques.

Learners will develop their knowledge and understanding of, and skills in:

- Installing, commissioning and maintaining refrigeration systems
- The hazards, health and safety and environmental requirements when working on a refrigeration system
- Identifying and selecting the correct tools and equipment for a specific task.
- Fabricating pipework and pressure testing pipe a refrigeration system to ensure it is leak-free
- Fault-finding mechanical and electrical problems in refrigeration systems

Learners may be introduced to this specialism by asking themselves questions such as:

- How does a refrigeration technician minimise the environmental impact of a refrigeration system?
- What are the requirements of the F-Gas regulations?
- What tools and equipment does a refrigeration technician need?

**Underpinning knowledge outcomes**

On completion of this specialism, learners will understand:
1. Refrigeration knowledge criteria

**Performance outcomes**

On completion of this specialism, learners will be able to:
2. Install refrigeration systems
3. Commission refrigeration systems
4. Maintain refrigeration systems

Completion of this specialism will give learners the opportunity to develop their Maths, English and Digital Skills. Details are presented at the end of the specification.
Specialism content

1. Refrigeration knowledge criteria

Criteria

Tools, equipment and materials

1.1 Types of fluids.

Range:
Fluids - primary refrigerants (CFC, HCFC, HFC, HFO, HC, Natural), secondary refrigerants (glycols), lubricants (Mineral, synthetic), refrigerant vapour / liquid, saturated refrigerant fluids.

What do learners need to learn?

How to identify the refrigerant state at different parts of the system and the effect fluid flow has on oil return to the compressor. Different types of liquids and gases, how they flow and the effect of different pipe sizes on flow. The velocity for oil return, effect of pressure drop on system performance, suction and liquid risers.

1.2 The safe recovery, recycling and disposal of equipment and hazardous waste transfer.

What do learners need to learn?

Methods of safe recovery, recycling and disposal of equipment and hazardous waste transfer. How to safely recover refrigerant from a system in accordance with all environmental legislation (F-Gas regulations, Hazardous Waste Regulations). Reclalm and recycling methods, safe electrical isolation and the use of Waste Transfer Notes.

Legislation, Regulations and Standards

1.3 Key requirements of environmental legislation.

Range:
Environmental legislation - Climate Change Act, Control on Ozone-Depleting Substances, F-Gas regulations, Environmental Protection Act, Hazardous Waste Regulations.

What do learners need to learn?

The key requirements of current environmental legislation and their relation to refrigeration systems. The responsibilities under the requirements of the legislation.
Refrigeration systems

1.4 Processes of refrigeration cycles.

Range:
Processes - temperature scales (Celsius, Kelvin), laws of thermodynamics (First law, second law), heat transfer (Conduction, convection, radiation), latent heat processes (Melting (Fusion), freezing, sublimation, condensation, evaporation, boiling), sensible heat processes (Super heating, sub-cooling), evaporation, compression, condensation and expansion processes.

What do learners need to learn?
The different heat transfer and state-changes that occur around a refrigeration circuit, and the expected pressures and temperatures at different points in the system.

Skills

1.5 Performance parameters for running a refrigeration cycle.

Range:
Performance parameters - suction and discharge pressures, saturated suction / discharge temperatures, superheat, subcooling, storage set-points, running currents, refrigerants (HFC, HC, HFO, natural)

What do learners need to learn?
The ideal running pressures, temperatures and electrical currents for a range of refrigeration systems using different refrigerants.

Skills
1.6 Refrigeration system **components.**

**Range:**

**Components -**
- **Compressors** - reciprocating, rotary vane, scroll, centrifugal
- **Condensers** - air, liquid cooled, evaporative
- **Evaporators** - forced draft, induced draft, natural convection, liquid cooling, direct expansion, flooded
- **Expansion devices** - capillary tube restrictor, thermostatic expansion valves (internally and externally equalised), linear/electronic expansion valves, liquid level control
- **Ancillary components** - liquid and suction line driers, pressure relief valves, strainers, oil separators, moisture indicating sight glass, service valves
- **Storage vessels** - suction line accumulator, high pressure receivers
- **Control valves** - four way reversing, solenoid, evaporator, crankcase, differential pressure regulators, non-return valves
- **Fans** - axial, propeller, centrifugal

**What do learners need to learn?**

The function and operation of a range of components and how they interact in a range of different systems and applications to operate effectively

**Skills**

1.7 Types of components for **refrigeration systems.**

**Range:**

**Refrigeration systems** - direct expansion, flooded, pump overfeed, cascade, compound, booster, trans critical, blast freezing, cold storage, chill storage

**What do learners need to learn?**

The different types of components and their suitability in different situations to meet differing client needs.

**Skills**

**Refrigeration engineering science**

1.8 Methods to apply **ideal gas laws.**

**Range:**

**Ideal gas laws** - Boyle’s law, Charles’ law, Combined gas law, Dalton’s law

**What do learners need to learn?**

Methods to apply the gas laws for common refrigeration operations such as evacuation and pressure testing and when adaptations to a refrigeration system are needed. Units of pressure (Pascal, Bar, Millimetres of Hg, Torr) and Pressure scales (Absolute, gauge, vacuum) related to gas laws

**Skills**
1.9 How to show a refrigeration cycle on pressure-enthalpy charts.

**Range:**

**Refrigeration cycle** - evaporation, compression, condensation and expansion processes.
Refrigeration effect, compressor work done, total heat rejection, dryness fraction, subcooling, useful and non-useful superheat

**What do learners need to learn?**

How to plot a refrigeration cycle onto a pressure-enthalpy chart and identify the key thermodynamic processes.

1.10 Interpret refrigeration data from pressure-enthalpy charts.

**Range:**

**Data** - work done, refrigeration effect, total heat rejected, Coefficient of Performance, mass flow rate, pressure ratio, compressor power input, specific volume at suction, cooling capacity, heating capacity (total rate of heat rejection)

**What do learners need to learn?**

How to perform calculations using refrigeration data on pressure-enthalpy charts to determine cooling capacity, refrigerant flow rate, total heat rejection and compressor swept volume.

1.11 **Ideal properties** of refrigerant fluids and lubricants.

**Range:**

**Ideal properties** –

**Primary refrigerant ideal properties** - has an odour, non-flammable, non-toxic, miscible with oil, high latent heat value, easily leak detectable, efficient pressure ratio, non-ozone depleting, non-global warming potential, high dielectric strength, high density.

**Secondary refrigerant ideal properties** - low viscosity, non-toxic, non-flammable, high specific heat value, low cost, non-corrosive, low freezing point
Environmental impact: Ozone depletion, global warming /climate change.

**Refrigerant Hazard groups** - A, B, 1, 2L, 2, 3.

**Ideal Properties of lubricants** - low floc point, low pour point, low viscosity, high dielectric strength, low foaming tendency, high flashpoint, low hygroscopic effect, low acidity, low moisture content, low toxicity, high miscibility with refrigerant.

**Refrigerant fluids** -

**Primary refrigerants** - HFC, HFO, HC, Natural refrigerants.

**Secondary refrigerants** - water, propylene glycol, ethylene glycol, brines.
<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ideal properties of a range of refrigerants and lubricants and their uses for a range of refrigeration applications. The implications for their use in refrigeration systems.</td>
<td></td>
</tr>
</tbody>
</table>

1.12 Types of **monitoring systems**.

**Range:**
**Monitoring systems** - local, remote, building management system, pack control systems.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The different types of monitoring equipment and how they can be used to reduce the environmental impact of a refrigeration system. The types of data produced by systems and how the data is produced and extracted. The different types of wireless systems available.</td>
<td></td>
</tr>
</tbody>
</table>

**Sustainability**

1.13 **Environmental impact** of refrigerants.

**Range:**
**Environmental impact** - F-Gas regulations, phasedown of refrigerants, effect on global warming /climate change and ozone depletion.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The environmental impact that different refrigerants have on climate change, their Ozone Depletion Potential (ODP) and their Global Warming Potential (GWP).</td>
<td></td>
</tr>
</tbody>
</table>

1.14 **New developments** in refrigeration.

**Range:**
**New developments** - low GWP refrigerants (HFO, HC, Natural), safety classifications

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>New developments in the RAC industry to reduce the environmental impact of refrigerant gases. Their potential uses in refrigeration systems and associated toxicity and fire risks.</td>
<td></td>
</tr>
</tbody>
</table>
1.15 Maximise efficient refrigeration system performance.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods to maximize efficiency of a refrigeration system through the selection of refrigerants and components and setting them up correctly to mitigate direct and indirect carbon emissions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Skills</th>
</tr>
</thead>
</table>
Specific knowledge criteria for performance outcomes

System Installation (PO2)

1. Refrigeration knowledge criteria

1.16 **Methods** for checking refrigeration system leakages.

**Range:**
**Methods** - strength and tightness testing, use of inert gases, electronic leak detection, leak test fluids, UV dye.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The methods used to check refrigeration systems for leakages in accordance with the F-Gas regulations and BS EN 378-2016.</td>
<td></td>
</tr>
</tbody>
</table>

1.17 Types of **substrates**.

**Range:**
**Substrates** - insulated panels, brickwork, plasterboard, concrete.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The tools and equipment (power drills, types of drill bit) required for fixing a range of system components to a range a wall, floor and ceiling substrates. The implications for refrigeration system installation.</td>
<td></td>
</tr>
</tbody>
</table>

1.18 Types of **protective materials**.

**Range:**
**Protective materials** - thermal insulation materials

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The different types of insulation material used to protect against heat gain/loss and electric shock. Their properties and how to ensure the material operates effectively.</td>
<td></td>
</tr>
</tbody>
</table>
1.19 Types of pipework.

Range:
Pipework - copper, steel, aluminum

What do learners need to learn?  
Different types of pipework and their suitability for different purposes.

Skills

System commissioning (PO3)

1.20 System operation requirements.

What do learners need to learn?  
The checks required for commissioning including after a long period of non-use.

The range of tests and measurements needed to ensure a refrigeration system is operating at maximum efficiency, visual checks, strength test, tightness test, evacuation, charging, system running, measure (Superheat, Subcooling, Evaporator air on and off temperature, Running currents, Refrigerant type and quantity, condenser air on and off) and coil approach temperatures.

Skills

1.21 Visual inspection of a refrigeration system.

Range:
Visual inspection - use of human senses (sight, sound, smell, touch)

What do learners need to learn?  
Visual inspection of a refrigeration system to determine if any fault conditions are present.

Skills

1.22 Expectations of a steady state operation for refrigeration system.

What do learners need to learn?  
Expectations of a refrigeration system when it is running at the correct steady state conditions, including after long period on non-use. The checks required to confirm expectations include suction and discharge pressures, saturated suction/ discharge temperatures, superheat, subcooling, storage set-points, running currents.

Skills
1.23 Types of fault finding techniques.

Range:
Fault finding techniques - use of human senses (sight, sound, smell, touch), customer reports, historical records, manifold gauges, electrical test meters, safe electrical isolation.

What do learners need to learn?
Types of fault finding techniques and diagnostic equipment, and how these are applied to determine a range of mechanical and electrical faults on a refrigeration system. The suitability of different fault finding techniques for different situations and how they are applied in practice.

Skills

1.24 Cleaning of components.

Range:
Components - coils, drain pans, drain lines.

What do learners need to learn?
The components that require cleaning and how to clean without compromising system. The tools, equipment and materials used to clean components; pressure washers and cleaning fluids.

Skills

1.25 Disassembly techniques.

Range:
Techniques - unbrazing, flaring.

What do learners need to learn?
Considerations required to safely disassemble a refrigeration system and its components prior to repair or replacement of individual components.

Considerations to include - use of tools, safe electrical isolation, refrigerant recovery. Documents Reference documents to include - manufacturer’s instructions, method statements, risk assessments.

Skills
1.26 **Methods** to extract refrigerant.

**Range:**
**Methods** - recover, reclaim and recycling methods, safe electrical isolation.

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
<th><strong>Skills</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods to safely remove refrigerant from a system in accordance with the F-Gas regulations and all current environmental legislation; Hazardous Waste Regulations. The purpose of Waste Transfer Notes, Methods to safely handle and manage refrigerant once extracted.</td>
<td></td>
</tr>
</tbody>
</table>
## Performance outcome 2 - Install refrigeration systems

### 2.1 Sequence and prioritise tasks.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpret the customers’ requirements and plan the installation to cause minimum disruption and liaise with other trades to avoid conflict. Plan execution of program of works, liaison with other trades, method statements and risk assessments.</td>
<td>EC1, EC4, EC5</td>
</tr>
</tbody>
</table>

### 2.2 Identify **information requirements** from a brief.

**Range:**

**Information requirements** - drawings, manufacturer’s specifications, regulatory documents, industry codes of practice, manufacturers’ instructions, installation specifications, permits to work, method statement, risk assessment.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify all the information needed from a range of sources to ensure compliance with local and national by-laws and legislation and any specific manufactures requirements.</td>
<td>EC4, EC5</td>
</tr>
</tbody>
</table>

### 2.3 Gather required **information**.

**Range:**

**Information** - manufacturer’s instructions, non-domestic building services compliance guide, Building Regulations, local by-laws

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gather all necessary information from a range of sources to ensure compliance with local and national by-laws and legislation and any specific manufactures requirements</td>
<td>EC4</td>
</tr>
</tbody>
</table>
2.4 Interpret **information and data**.

**Range:**
**Information and data** - manufacturer’s instructions, non-domestic building services compliance guide, Building Regulations, local by-laws

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpret all the information gathered to plan the installation of the refrigeration system.</td>
<td>EC4, EC5, MC6</td>
</tr>
</tbody>
</table>

2.5 Calculate **data required**.

**Range:**
**Data required** - heat gains in cold rooms, product cooling loads, component selection, ideal storage temperatures.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculate the heat gain into a cold room and determine the product cooling load as well as determine the ideal storage temperature.</td>
<td>MC2</td>
</tr>
</tbody>
</table>

2.6 Produce written **reports** to stakeholders about work completed.

**Range:**
**Reports** - handover information, operation instructions, F-Gas records, maintenance instructions, job sheet/card, commissioning record.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce written completion documentation for legal compliance (F-gas records) and customer information (operation instructions).</td>
<td>EC1, EC3</td>
</tr>
</tbody>
</table>

2.7 Measure and mark out **installation requirements**.

**Range:**
**Installation requirements** - pipe routes, location of evaporator coils (coolers), condensing units, services (electricity, gas, water, drainage, ventilation).

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locate and mark out the location of indoor and outdoor sections of the system together with pipe routes for refrigerants, water, drainage and electrical cabling.</td>
<td>MC1</td>
</tr>
</tbody>
</table>
2.8 Drill holes for fixings in various **substrates**.

**Range:**
**Substrates** - insulated panels, brickwork, plasterboard, concrete.

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
<th><strong>Skills</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Drill the correct size hole for a range of fixings in a variety of wall materials.</td>
<td>MC1</td>
</tr>
</tbody>
</table>

2.9 **Position components**.

**Range:**
**Position** – levelling, squaring
**Components** - coolers, condensers, condensing units, control panels, pipe routes.

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
<th><strong>Skills</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine the ideal position for the internal and external components with regard to servicing and maintenance requirements and energy efficiency.</td>
<td>MC1 MC2</td>
</tr>
</tbody>
</table>

2.10 Insert **protective materials** into drilled holes.

**Range:**
**Protective materials** - conduits, trunking, fireproof insulation, intumescent mastic

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
<th><strong>Skills</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>To fix protective materials into wall penetrations to prevent collapse and spread of fire.</td>
<td></td>
</tr>
</tbody>
</table>

2.11 Cut **pipework**.

**Range:**
**Pipework** - copper, steel, aluminium

<table>
<thead>
<tr>
<th><strong>What do learners need to learn?</strong></th>
<th><strong>Skills</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut and prepare refrigeration pipework and conduit to required dimensions, ready for connection to other components.</td>
<td></td>
</tr>
</tbody>
</table>

---
2.12 Manually bend **pipework**.

**Range:**
*Pipework* - copper, steel, aluminium.

**What do learners need to learn?**
Manually bend a range of refrigeration pipes and conduits to suit the installation requirement, to include 90°, 280° and offset bends.

**Skills**
MC1

2.13 Assemble pipework.

**What do learners need to learn?**
Join refrigeration pipework and components using brazing, flaring and swaging methods (Cu to Cu, Cu to Fe, Cu to brass, Fe to Brass).

**Skills**

2.14 Permanently fix indoor and outdoor units.

**What do learners need to learn?**
Permanently fix a range of refrigeration components and supports including pipework and cabling to different wall, ceiling and floor materials; Insulated panels, brickwork, plasterboard, concrete.

**Skills**

2.15 **Leak test** system inert gas.

**Range:**
*Leak test* - strength and tightness testing, pressure testing using inert gas, soap solutions, proprietary leak test solutions.

**What do learners need to learn?**
Leak test a refrigeration system in accordance with the requirements of the F-Gas regulations using inert gases prior to commissioning.

**Skills**
Performance outcome 3 - Commission refrigeration systems

3.1 Interpret a risk assessment.

What do learners need to learn?
Interpretation of risk assessments with consideration to responsibilities, persons at risk and applying controls, recording potential hazards and completion of documentation.

Skills
EC4
EC5

3.2 Interpret information provided.

Range:
Information - BS EN378, F-Gas regulations, contractual specifications, manufacturer’s instructions, including tabular and graphical information.

What do learners need to learn?
Interpretation of regulatory, contractual and manufacturer’s specifications and requirements in readiness to carryout system commissioning.

Skills
EC4
EC5

3.3 Collect data from control system.

Range:
Data - superheat, subcooling, coil approach temperature (delta T), air flow, air distribution, air on and off temperature, oil pressure, system running pressures, running current, relative humidity, primary and secondary refrigerant flow rates, temperature set-points.

What do learners need to learn?
Access the system and its controls to collect a range data.

Skills
MC5
MC6
DC4

3.4 Interpret commissioning data collected.

Range:
Data - superheat, subcooling, coil approach temperature (delta T), air flow, air distribution, air on and off temperature, oil pressure, system running pressures, running current, relative humidity, primary and secondary refrigerant flow rates, temperature set-points.

What do learners need to learn?
Interpret recorded data to ensure the design conditions and parameters are met.

Skills
MC6
DC4
EC5
3.5 Discuss requirements with stakeholders.

**Range:**
**Requirements** - product load, types of product stored, required storage temperatures, access and usage.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use open questioning and listening techniques to ensure that the end user/ client’s requirements and needs are met.</td>
<td>EC2 EC4 EC5 EC6</td>
</tr>
</tbody>
</table>

3.6 Inspect system installation.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct visual inspections of the complete system to ensure all works are complete, safe and meet the specification before commencement of the commissioning activity. Check to ensure systems are leak free, clean and fixings are secure.</td>
<td></td>
</tr>
</tbody>
</table>

3.7 Establish a **steady state** operation.

**Range:**
**Steady state** - storage temperatures, operating pressures, superheat, subcooling, running current, air flow rates.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use commissioning instruments to collect and record data such as temperatures, systems pressures, flow rates and running currents. Interpret the data readings recorded to ensure that the steady state conditions achieved meet the contractual requirements.</td>
<td>MC6 DC3</td>
</tr>
</tbody>
</table>

3.8 **Adjust** system for optimum performance.

**Range:**
**Adjust** - storage temperature, safety controls (high and low pressure), air flow rates, head pressure controls, position of sensors, energy efficiency.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use the measured commissioning data to adjust the refrigeration system to achieve the required storage conditions, set all safety controls and ensure maximum energy efficiency.</td>
<td>MC6</td>
</tr>
</tbody>
</table>
3.9 Record **test results**.

**Range:**

**Test results** - superheat, subcooling, coil approach temperature (delta T), air flow, air distribution, air on and off temperature, oil pressure, system running pressures, running current, relative humidity, primary and secondary refrigerant flow rates, temperature set-points.

**What do learners need to learn?**

Record all commissioning data and set points in accordance with the client's requirements, F-Gas regulations and future reference (service activities).
Performance outcome 4 - Maintain refrigeration systems

4.1 Produce a **method statement**.

**Range:**
**Method statement** - scope of works, manufacturer’s instructions, contractual requirements, risk assessment, preventative or reactive maintenance, permits to work.

**What do learners need to learn?**

Produce a method statement and risk assessment for either preventative or reactive maintenance through interpretation of system data, customer reports or contractual requirements.

**Skills**

| EC1 | EC2 | EC4 |

4.2 Assess suitability of **information** provided.

**Range:**
**Information** - sufficiency, accuracy, currency, previous service records, F-Gas records, customer, senses, site logs.

**What do learners need to learn?**

Consider all of the information available with regard to its accuracy and reliability before creating a maintenance plan.

**Skills**

| EC4 | EC5 |

4.3 Calculate **resource requirements**.

**Range:**
**Resource requirements** - refrigerant type and quantity, lubricants, cleaning agents, spare parts, consumables.

**What do learners need to learn?**

Consider the maintenance plan and manufacturers instruction to calculate and compile a list of all materials needed to complete the maintenance task.

**Skills**

| MC2 | EC3 |
4.4 Complete **documentation**.

**Range:**
**Documentation** - maintenance plan, maintenance report, site logs, F-Gas records.

**What do learners need to learn?**
Complete all documentation in line with contractual and legislation requirements.

**Skills**
EC3

4.5 Produce **technical reports**.

**Range:**
**Technical reports** - maintenance reports, maintenance plans and schedules, site logs, F-Gas records.

**What do learners need to learn?**
Complete service and maintenance site reports on work carried out and update site logs and F-Gas records.

**Skills**
EC3

4.6 Visually inspect the system.

**What do learners need to learn?**
Carry out a visual inspection of the system first, with consideration given to health and safety and possible faults that may not be apparent to the client/customer. Visual inspection to include security of pipework, vibration mounts, corrosion, refrigerant or water leaks, mechanical damage, loose screws or connectors.

**Skills**

4.7 Clean **system**.

**Range:**
**System** - evaporator and condenser coils, air filters, water filters, drain pans, drain lines, unit casings

**What do learners need to learn?**
Carry out a wide range of cleaning activities with consideration given to health and safety and maintaining maximum energy efficiency.

**Skills**
4.8 Extract **components** from the system.

**Range:**
**Components** - compressors, driers, fan motors, defrost heaters, expansion devices, refrigerants, solenoid valves, pressure control valves.

**What do learners need to learn?**
Remove and replace a variety of components from a refrigeration system ensuring all health and safety and environmental considerations are followed.

**Skills**

4.9 Apply **fault finding techniques** to identify faults.

**Range:**
**Fault finding techniques** - data analysis, leak-testing, operational logs, F-Gas records.

**What do learners need to learn?**
Apply a range of fault-finding techniques such as data analysis, observation of running conditions, review of operation logs and past service reports to identify a range of mechanical and electrical faults.

**Skills**

MC2
MC6
DC4
EC5

4.10 Rectify **faults**.

**Range:**
**Faults** - poorly fitted insulation, broken or blocked condensate drain, incorrectly set controls, component failure

**What do learners need to learn?**
Replace or repair a range of system faults and components to return a refrigeration to full operational condition.

**Skills**

EC1
EC2
EC3
EC6

4.11 Report on maintenance concerns.

**What do learners need to learn?**
Produce verbal and written reports based on the recorded data and the results of the inspection and any maintenance concerns; hot running compressor, evidence of leaks, not maintaining temperature, system trips, product loading, air flow.
4.12 Classify waste for disposal and recycling.

Range:
Waste - refrigerants, lubricants, pipework, valves, driers.

What do learners need to learn?
Identify a range of waste materials produced during a service and maintenance activity in accordance with the Hazardous Waste regulations and the F-Gas regulations.

Skills
Refrigeration

Links to Core Skills

As part of delivery of the skills and knowledge within this specialism reference should be made to criteria that support the development of the four core skills – communication, working collaboratively, problem solving and research. Some examples of criteria that may be linked to supporting these core skills include:

- Communication e.g. providing information and advice to customers and / or wider stakeholders on the potential risks of a change to an industrial system, or making a presentation to a stakeholder on the implications of change.

  **Example criteria**
  - 2.6/3.5 will support a learner’s personal development in how to communicate with others, by producing written reports to stakeholders about work completed.

- Applying a logical approach to solving problems, identifying issues and proposing solutions e.g. through setting criteria for successful implementation of a system, using cost / benefit analysis of the introduction of new procedures or equipment.

  **Example criteria**
  - 4.9/4.10 will support a learner’s personal development in how to apply a logical approach to solving problems by applying fault finding techniques and repairing and rectifying any faults identified to return system to full operation.

- Primary research e.g. obtaining measurements related to a design and / or customer requirements.

  **Example criteria**
  - 3.7 will support a learner’s personal development in how to research by using and commissioning instruments to collect, record and interpret data to ensure that steady state conditions meet contractual requirements.

Core content

All aspects of the common core and BSE specific core content can be related and contextualised on delivery in relation to this specialism. However, the following are **key areas** of the content that may be **of particular relevance** when delivering the knowledge and practical content for this specialism and may provide efficiencies for teaching core knowledge in context;

**Common core content**

- Construction sustainability principles - Energy production and energy use and waste management
- Environmental impact
- Construction information and data principles – Standards, regulations and guidance

**BSE specific core content**

- Health and safety - BSE Regulations and safe working practices
- Building Services Engineering (BSE) systems
- Tools and equipment – Use and maintenance

Aspects of the refrigeration specialism can also be closely linked to the air conditioning specialism. For learners taking both the air conditioning and refrigeration specialisms, opportunities for efficiencies in delivery include:

- Tools, equipment and materials
- Fault finding techniques
• Interpreting and producing written information
• Calculations and measurements of data

**Guidance for delivery**

• Opportunities for efficiencies in delivery

There are opportunities to consolidate learning where elements of content are common across performance outcomes, for example:
  o Jointing
  o Charging
  o Recovery

Where content is common across installation, commissioning and maintenance activities, it is recommend that these are delivered once and contextualised where needed.

• Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery
• Formative assessment – oral Q&A, SmartScreen worksheets (samples available) observation of measuring activities
  o Practical - Use of pre-set formative assessments carry out tasks and record on standardised form. Use of a variety of measuring instruments
  o Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT

• Ways of ensuring content is delivered in line with current, up to date industry practice
  o Delivery for this specialism will take place in a dedicated refrigeration classroom/workshop
  o A realistic representation of refrigeration systems and components should be installed in the classroom/workshop
  o Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
  o The provision must represent the type of equipment currently available in the UK refrigeration industry
  o New and emerging refrigeration technology should be included in the delivery

**Suggested learning resources**

**Books**

• Refrigeration Equipment. A servicing & Installation handbook
• Principles of Refrigeration 5th Edition
• Refrigeration & Air Conditioning
• The Motivate Series. Refrigeration & Air Conditioning Technology
• Modern Refrigeration & Air Conditioning 19th Edition
• Refrigeration and Air Conditioning (5th edition)
• BRA Guide to good commercial refrigeration practice

**Websites**

• [www.iorg.org.uk](http://www.iorg.org.uk)
• BSEN378:2016 standard [www.shop.bsigroup.com](http://www.shop.bsigroup.com)
• [www.acrib.org.uk](http://www.acrib.org.uk)
• www.summitskills.org.uk
• F Gas www.gov.uk
• F-Gas www.refcom.org.uk
What is this specialism about?

The purpose of this specialism is for learners to understand and undertake fundamental ventilation work. Learners will have the opportunity to plan, perform and evaluate their work whilst utilising a range of materials, methods and techniques.

Learners will develop their knowledge and understanding of, and skills in:

- Fundamental health and safety practices associated with carrying out ventilation installation work
- Technical terms, data and units of measurement in ventilation systems design and installation
- Ventilation systems and their purpose (mechanical and natural ventilation)
- Ventilation systems tools, equipment and controls
- Ductwork materials (metal and non-metal) fittings, installation processes and jointing methods

Learners may be introduced to this specialism by asking themselves questions such as:

- What kind of tasks are carried out by a ventilation system installer?
- What types of systems does a ventilation installer work on?
- What tools and equipment are used by a ventilation installer?

Underpinning knowledge outcomes

On completion of this specialism, learners will understand:

1. Ventilation knowledge criteria

Performance outcomes

On completion of this specialism, learners will be able to:

2. Install ventilation systems
3. Commission ventilation systems
4. Maintain ventilation systems

Completion of this specialism will give learners the opportunity to develop their Maths, English and Digital Skills. Details are presented at the end of the specification.
Specialism content

**Common knowledge criteria**

**Health and safety**
1.1 **Typical hazards** and **safe systems** of work specific to ventilation engineering.

**Range:**
**Typical hazards** - Legionnaires disease risk in ventilation systems, asbestos insulation risk in ventilations systems (risk to installers and building occupants)

**Safe systems of work** - risk assessment and Method Statement (RAMS), safe isolation techniques

**What do learners need to learn?**

Key requirements of Approved Codes of Practice (ACOPs).

Roles and responsibilities for safety under relevant legislation, codes of practice and permits to work. Typical hazards and the safe systems of work (e.g. method statements) used in ventilation engineering.

Implications of poor health and safety performance e.g. indoor air quality (IAQ), dust, contaminants, odours.

**Ventilation systems**
1.2 **Types of systems.**

**Range:**
**Systems** - mechanical ventilation, natural ventilation, mixed mode ventilation

**What do learners need to learn?**

The main types of ventilation systems, their basic functions, typical environments of occupied spaces in buildings, variations for special environments (e.g. cleanrooms, hospital operating theatres, scientific laboratories, swimming pools, toilet extracts etc.) and key considerations for installation and maintenance. Purposes, similarities and differences in operation
1.3 Mechanical components.

Range:

**Mechanical components** - fans, filters, dampers, air to air heat exchangers

What do learners need to learn?  
Mechanical components used in ventilation engineering systems, their function and performance characteristics and the implications to the system of component failure

Skills

1.4 Electrotechnical components.

Range:

**Electrotechnical components** - inverters, actuators, sensors.

What do learners need to learn?  
Electronic components (e.g. thermostat, humidistat, anemometer, manometer etc.) used in ventilation engineering systems, their function and performance characteristics. Implications to the system of component failure.

Skills

1.5 Types of control system.

Range:

**Control system** - Building Management System (BMS), stand alone, time clock, manual on of

What do learners need to learn?  
The types of controls required in ventilation engineering systems. The purpose of different controls, their components, similarities and differences and efficiencies.

Skills
1.6 The importance of system cleanliness

**What do learners need to learn?**

The importance of cleanliness. Cleanliness industry standards and guidance. The methods used to achieve system cleanliness pre and post installation.

The implications for system performance and health and wellbeing of building occupants of poor cleanliness standards in ventilation systems.

**Tools, equipment and materials**

1.7 **Tools, equipment** and **materials**.

**Range:**

**Tools** - power tools, hand tools

**Equipment** - portable access equipment, anemometer, flow meter, temperature sensors, balometer (flow hood)

**Materials** – rigid, semi-rigid, flexible, thermal insulation, jointing compounds, seals and tape

**What do learners need to learn?**

Common equipment, tools and materials and their purpose.

1.8 Operation and handling requirements

**What do learners need to learn?**

The importance of protecting ventilation system components (ductwork) during delivery from a manufacturer (fabrication location) and others in the supply chain to a site delivery address (Pre-Delivery and Installation (PDI) levels). The importance of correct on-site storage and handling.
### Ductwork science

1.9 Types of ductwork and in-line system components and their suitability for different systems.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The types of ductwork and in-line system components, their function and technical performance characteristics. The nature of the environment and its effect on ductwork and components, IP ratings of electrical components, corrosion of metallic elements, durability of plastic, flexible and fabric ductwork.</td>
<td></td>
</tr>
</tbody>
</table>

1.10 Types of linings, coatings and identification labels.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The types of ductwork linings, coatings and their characteristics, their use for different purposes/ applications and suitability for different systems. The purpose of identification labels.</td>
<td></td>
</tr>
</tbody>
</table>

1.11 Types of ductwork materials.

**Range:**

**Materials** – rigid, semi-rigid, flexible, fabric.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The range and types of ductwork materials, their function and technical performance characteristics (e.g. strength and durability etc.). Their use in specialist situations such as swimming pools. Their properties (e.g. fire ratings, thickness gauges etc.) and suitability for different systems.</td>
<td></td>
</tr>
</tbody>
</table>
1.12 Types of thermal insulation materials.

Range:
Thermal insulation materials - rockwool insulation, phenolic insulation.

What do learners need to learn?
The types of ductwork thermal insulation materials, their function and technical performance characteristics (e.g. thermal conductivity, thermal resistance etc.). Their properties and suitability for different systems.

Skills

1.13 Types of support.

Range:
Support - fittings (clips, brackets), Fixings (uni-rail, threaded bar)

What do learners need to learn?
The types of ductwork fittings and fixings for structural integrity, their function and technical performance characteristics (e.g. tensile strength, maximum load) and their suitability for different systems.

Skills

Information and data

1.14 Asbestos register and legionella control logbook.

What do learners need to learn?
Systems of recording information and data related to safety. The contents and importance of the asbestos register and legionella control logbook as well as minimising sources of other airborne contaminants.

Skills
1.15 Indoor air quality requirements for different situations.

**What do learners need to learn?**

The requirements for indoor air quality for different building situations to ensure health and wellbeing for building occupants. The air quality for typical environments of occupied spaces in buildings (toilets, kitchens, offices, classrooms, hotel rooms) as well as variations for special environments (hospital operating theatre, museums, computer chip manufacturing, data centres, pharmaceutical manufacturing, food manufacturing).

**Skills**

EC3
EC5
DC5

1.16 Types of documentation produced.

**Range:**

**Documentation** - commissioning certificates, manufacturer’s data sheets, asset lists, as built drawings

**What do learners need to learn?**

Types of documentation, their content and purpose. QA systems for documentation. The importance of file management, file sharing and specific document version control.
Specific knowledge criteria for performance outcomes

**System commissioning (PO3)**

1.17 Positive and negative pressure classification, air tightness and system balancing.

### What do learners need to learn?  | Skills
---|---
Ductwork operating pressures, integrity of ductwork and acceptable leakage rates. Positive and negative pressure ventilation systems.

1.18 Types of **checks** and **tests**.

**Range:**

**Checks** - visual inspection (system integrity, system cleanliness)

**Tests** - system balance, set to work, airflows, volume, pressure, temperature, BMS point-to-point and functional tests, post clean vacuum testing

### What do learners need to learn?  | Skills
---|---
Types of checks and tests, their purpose and the techniques to be applied. The importance of completing commissioning checks and procedures. Commissioning and testing principles for ventilation ductwork, mechanical fans and natural ventilation systems. Relevant testing and commission references, Building Regulations Approved Document F (fan flow rate testing), DW/111 or BSRIA BG19 (ductwork systems testing) and BSRIA TN 11/95 (natural ventilation design). The mechanical fan flow rates and testing methods and instrumentation (vane anemometer). Natural ventilation design strategies and post-construction testing (single sided, crossflow, stack effect and atria designs).

1.19 Purpose of maintenance activities.

### What do learners need to learn?  | Skills
---|---
The main purposes of maintenance in ventilations systems (e.g. ensuring fan operation is what is designed for comfort and health for building occupants, poor energy performance in a system leading to unnecessary building energy costs, poor environmental performance leading to higher levels of electricity demand and associated CO₂ emissions, excessive and uncomfortable noise and vibration levels in a part of a building). The implications of failure to maintain assets
1.20 **Contents** of a maintenance plan.

**Range:**

**Contents** - materials and spares, time needed.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The importance of a maintenance plan, including estimated times needed for repair and maintenance tasks and a reliable inventory system for quantities of spare materials and components that should be stored on site for quick and easy access. The time between planned maintenance activities</td>
<td>EC1, EC3</td>
</tr>
</tbody>
</table>

1.21 **Types of maintenance**.

**Range:**

**Maintenance** – planned, total Preventative Maintenance (TPM), breakdown/reactive.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
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</tr>
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<tbody>
<tr>
<td>The types of maintenance activities carried out in ventilation systems, their specific benefits and limitations. The main types: planned maintenance and emergency maintenance and variations of these. Communication methods for reporting maintenance faults to a facilities team</td>
<td>EC1, EC3, EC6, DC3</td>
</tr>
</tbody>
</table>

**System maintenance (PO4)**

1.22 **Cutting techniques.**

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>The common tools, equipment and materials needed for cutting sections of ventilation ductwork.</td>
<td>MC1</td>
</tr>
</tbody>
</table>

1.23 **Mechanical joining techniques.**

<table>
<thead>
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<tbody>
<tr>
<td>The common tools, equipment and materials needed for joining sections of ventilation ductwork.</td>
<td></td>
</tr>
</tbody>
</table>
1.24 Assembly and disassembly techniques.

**What do learners need to learn?**
The access equipment for safely accessing to assemble and take apart ductwork sections.

**Skills**

1.25 Fault finding.

**What do learners need to learn?**
Fault finding techniques (e.g. electronic sensors sending signals to a BMS indicating a fault on supply or extract ductwork flow rate, air pressure, temperature or humidity, power failure). Unusual reading of CO\(_2\) concentration in a room or building zone or operational faults in mechanical fans, at supply or extract grilles or exhaust outlets. How fault finding techniques are applied and their suitability for different situations.

**Skills**

MC1
MC2

1.26 Waste management of decontaminated ductwork.

**What do learners need to learn?**
Maintenance best practice related to cleanliness and hygiene of ventilation systems. Regulations, procedures and guidance for ensuring the cleanliness of ventilation systems (air handling units, ductwork, fans, filters and all other associated components in ventilation systems).
The Building Engineering Services Association (BESA) (formerly the HVCA) publication TR/19 (Guide to Good Practice: Internal Cleanliness of Ventilation Systems). Other relevant regulations include the Workplace (Health, Safety and Welfare) Regulations 1992 ‘Regulation 6 Ventilation’. Important aspects will be e.g. dirt, dust, grease and other contaminants in ventilation ductwork systems.

**Skills**
Performance outcome 2 - Install ventilation systems

2.1 Interpret a risk assessment.

**What do learners need to learn?**

Review and assess any work task for its risk to health and safety with consideration of HSE guidelines, the CDM Regulations and the responsibilities of all employers and employees. Apply safety controls where identified by a risk assessment. Review and adjust a risk assessment where necessary. Consider COSHH in relation to extension of existing systems.

**Skills**

- EC4
- EC5

2.2 Interpret information provided.

**Range:**

Information – specification, drawings, locations of in-duct temperature and humidity sensors, local site considerations

**What do learners need to learn?**

Interpret information needed to install ventilation systems. Use specifications and plan layout drawings to identify ductwork routes and location of components. Create a materials list as required.

**Skills**

- EC5

2.3 Calculate installation requirements.

**Range:**

Installation requirements - thermal comfort of building occupants, supply ventilation, extract ventilation, mechanical ventilation, natural ventilation, positive and negative static pressure, Ductwork dimensions, Duct route lengths, Fan specification, Air velocity, Velocity and pressure, Structural load bearing, necessary fixings and support tolerances, Window opening sizes for natural ventilation airflow.

**What do learners need to learn?**

Determine ventilation installation requirements.

**Skills**

- MC1
- MC2
- MC6
2.4 Measure **ductwork requirements**.

**Range:**

**Ductwork requirements** - ductwork route lengths, location of fixings, locations of components

**What do learners need to learn?**

Measure ductwork route lengths, dimensions, fitting space and the locations of all ventilation components (fans, dampers, silencers, diffusers, inlet and extract grilles)

**Skills**

MC1

2.5 Mark out required measurements.

**What do learners need to learn?**

Measure positions in the building for the locations of ductwork fixings, routes and components to include on the building fabric (wall or ceiling) and on ductwork.

**Skills**

MC1

2.6 Prepare work areas for installation activities.

**What do learners need to learn?**

Prepare the work area appropriately and safely for all ventilation system ductwork and components by ensuring:

- Necessary access and space requirements to build a safe working platform
- Necessary lighting for the work tasks (general area lighting and task-specific spotlights)
- Necessary power for the work tasks equipment (e.g. power drills, ductwork cutting tools)
- Correct PPE
- All aspects of toolbox talks are considered

**Skills**

MC1
2.7 Position, fix, insert and secure ventilation ductwork.

**What do learners need to learn?**

Fixing procedures and tasks including various types of bearers and hangers for ductwork. Install rectangular, circular, rigid, semi-rigid, flexible and fabric ducting.

Install steel and aluminium ducting. Install ventilation ductwork components (e.g. fans, dampers, silencers, diffusers, inlet and extract grilles).

**Skills**

- MC1
- MC2

2.8 Apply internal ventilation ductwork coatings and linings.

**What do learners need to learn?**

Apply internal ductwork surface coatings for protection and maintenance planning reasons. Apply ductwork coatings and linings to protect internal surfaces from damage e.g. metallic corrosion. Apply ductwork coatings and linings to renew internal surfaces that have been damaged e.g. by corrosion.

**Skills**

- MC1

2.9 Test for air leakages and make corrections.

**What do learners need to learn?**

Test for air tightness (air leakages in ductwork) to ensure the integrity of the system and its airflow performance. Carry out air tightness tests for ductwork. Note the location of any ductwork air leakages for a repair and maintenance plan. Rectify and retest.

**Skills**

- MC1

2.10 Update digital building information management system software.

**What do learners need to learn?**

Record and update all digital building information management system software when new ventilation ductwork and components have been installed.

**Skills**

- DC1
- DC2
- DC3
- DC5
- DC6
### Performance outcome 3 - Commission ventilation systems

3.1 Assess risks associated with completing activities.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce, review and/or adjust risk assessment for commissioning tasks.</td>
</tr>
<tr>
<td>Complete commissioning and testing method statement.</td>
</tr>
<tr>
<td>Produce a risk assessment and method statement for ventilation system commissioning activities in accordance with the five stages of risk assessment:</td>
</tr>
<tr>
<td>• Identification of hazards e.g. working at height, working on a temporary work platform e.g. scaffold tower (medium risk) or step ladder (high risk)</td>
</tr>
<tr>
<td>• Identification of who is at risk and how</td>
</tr>
<tr>
<td>• Assessment of risk and action</td>
</tr>
<tr>
<td>• Recording of findings</td>
</tr>
<tr>
<td>• Review of risk assessment</td>
</tr>
<tr>
<td>• Method statements for work activities should be prepared to ensure that all commissioning technicians work to the same sequence and procedure, using the same tools and equipment and work in pairs or teams where required for safe working.</td>
</tr>
</tbody>
</table>

### What do learners need to learn?

Carry out commissioning tests to provide to the building owner or facilities management team full and accurate records of the performance of the installed ventilation system.

- Assess all essential commissioning and testing information for the installed system
- Prepare commissioning and testing checklist in a logical sequence for the site
- Complete commissioning records for the site
- Confirm testing instrumentation accuracy (calibration)
- Record all results accurately (operator).

### Skills

- EC1
- EC2
- EC3
- EC4
- EC5
- MC2
- MC6
- DC5

3.2 Assess suitability of information provided.
3.3 Interpret collected data.

**What do learners need to learn?**

Carry out preliminary checks of the building construction and the ventilation system to make sure they are at a point that is appropriate for commissioning and testing to take place e.g. checking that the ductwork is complete and meets required air leakage limits (pressure testing), is at a standard of cleanliness that is appropriate for the commissioning stage to be done.

Accurately interpret all ventilation system performance targets and actual test results and compare the two data sets to record if the actual results are within expected tolerances.

**Skills**

EC5  
MC6

3.4 Test system.

**What do learners need to learn?**

Carry out a testing and commissioning procedure for a ventilation system and its components. Fan switch on, initially at low load level, running at less than full load electrical current, checking for no excessive vibration or noise, checking for no overheating of the fan motor, then at full fan speed level.

- Set ventilation ductwork dampers to the correct position for the test (e.g. all fully open)
- Fan switch on and allow to run
- Check fan operation is correct
- Check initial air volume flow rate and fan pressures
- Record air volume flow rates (for comparison to design performance targets)
- Regulate air flow rates (system balancing)
- Test actuators for automatic window opening and automatic damper operation in a natural ventilation system

**Skills**

MC1  
MC10

3.5 Record test results.

**What do learners need to learn?**

Record performance test results in the system checks, including; test results for air volume flow rates and for various fan static pressures.

**Skills**

EC1  
EC3  
EC4
3.6 Annotate system profile and layout drawings reflecting system adaptations.

**What do learners need to learn?**
Annotate all system drawings and specifications to show fans and other system components.

Information could include fan pressure, volume flow rates delivered, motor current at various fan speeds, air temperature and humidity (psychrometry), component identification reference numbers, main ducts and branch duct routes, terminals types and locations and their air flow rates, controller test results for various set points.

Test results information to be annotated in schematic and layout drawings.

3.7 Update building information systems.

**What do learners need to learn?**
Update the building information system after the testing and commissioning has been completed.

Skills
DC1
DC2
DC3
DC4
DC5

3.8 Produce handover documentation.

**What do learners need to learn?**
Prepare all handover documentation for client/end user. Agree format for commissioning documentation appropriate for the building design and site location. Produce site asset list (ventilation system component, reference number, manufacturer, model, site location).

Record visual checks and preliminary checks notes in handover documentation. Record design performance and actual performance test results in handover documentation.

Skills
EC1
EC2
EC3
EC4
EC6
Performance outcome 4 - Maintain ventilation systems

4.1 Sequence and prioritise tasks.

**What do learners need to learn?**

Carry out tasks for both emergency maintenance and planned maintenance. Respond quickly to emergency maintenance e.g. an alert from BMS or client’s needs.

React and prioritise tasks depending on how critical the maintenance is.

Carry out planned maintenance with consideration of client’s needs to minimise any inconvenience.

Plan tasks using a maintenance schedule.

**Skills**

4.2 Identify information requirements.

**What do learners need to learn?**

Identify and correctly interpret maintenance needs in ventilations system for both planned and emergency maintenance.

Emergency maintenance could include, fan failure, temperature, humidity, CO₂ sensor readings not being what they should be or ductwork damage being visible (e.g. flexible ducting tear / puncture).

Planned maintenance could include, filter replacements, ductwork cleaning and visual inspection.

**Skills**

4.3 Gather required information.

**Range:**

**Information** - component manufacturer specifications for recommended maintenance requirements, commissioning and testing handover documentation, site registers, as-built schematic and layout drawings.

**What do learners need to learn?**

Gather all necessary information required for a maintenance task, including component manufacturer specifications or commissioning and testing handover documentation.

**Skills**

---

295
4.4 Calculate maintenance downtime.

**What do learners need to learn?**

Plan maintenance work schedules appropriately to minimize the system downtime in a building location with consideration to; downtime estimate for system maintenance, appropriate work planning schedule e.g. weekends or night hours, appropriate site access arrangements.

**Skills**

MC2

---

4.5 Convert imperial **measurements** to metric.

**Range:**

**Measurements** - airflow rates, air pressure, fan diameter, fan specification.

**What do learners need to learn?**

Convert imperial measurement to metric, for example - fan performance air flow rates in m³/s, m³/h and in cubic feet per minute (cfm).

**Skills**

MC1

MC4

---

4.6 Calculate resource and equipment requirements.

**What do learners need to learn?**

Plan maintenance work schedules appropriately to make sure that all necessary resources for a maintenance task are in place. Estimate required manpower, materials, tools and equipment for the system maintenance.

**Skills**

MC1

MC2

EC5

---

4.7 Discuss with client the effectiveness and efficient status of the installation.

**What do learners need to learn?**

Use open questioning and listening techniques to establish client needs with regard to the effectiveness of the ventilation system and adjust and adapt set points if necessary, to meet customer needs.

**Skills**

EC1

EC6
4.8 Clean system including pre-clean and post-clean testing.

**What do learners need to learn?**

Access and clean ventilation system ductwork and components (supply and extract grilles, fan motor casings, fan blades, filters, dampers etc).

Remove dust and other debris from all parts of a ventilation system to ensure it operates to its full performance level. Clean ductwork and components in-situ or remove for cleaning and replacement.

**Skills**

4.9 Handle all **materials** correctly and in a safe way.

**Range:**

**Materials** - refrigerants and chemicals used in ventilation industry, ductwork insulation materials.

**What do learners need to learn?**

Handle materials to maintain their integrity and that of the system, including the use of aggressive chemicals.

**Skills**

4.10 Identify root cause of **faults**.

**Range:**

**Faults** - ventilation system component failure, heating chilled water system component failure.

**What do learners need to learn?**

Respond to sensor alarms and building management system control panels to identify and understand the cause of ventilation system faults.

**Skills**

MC2
4.11 Apply **fault finding techniques** to rectify system operation.

**Range:**
**Fault finding techniques** - visual checks, performance testing, check operation of heating and cooling coils

**What do learners need to learn?**

Inspect faults in the ventilation system through visual checks and performance testing. Faults could be identified by electrical power failure, mechanical component failure e.g. grilles, filters, dampers not opening and closing properly or a ducting rupture (rigid, semi-rigid or flexible).

Use fault finding techniques to rectify fault and repair system operation. Inform responsible personnel of heating, cooling or electrical faults.

**Skills**
MC2
EC1
EC6

4.12 Measure **ductwork dimensions**.

**Range:**
**Ductwork dimensions** - rectangular ductwork dimensions, circular ductwork dimensions, fitting into building spaces, transformation sections (expansion and contraction).

**What do learners need to learn?**

Correctly measure ductwork dimensions: length, breadth, rectangular perimeter, circular circumference, diameter, radius and cross-sectional area.

**Skills**
MC1

4.13 Cut **ductwork**.

**Range:**
**Ductwork** - rigid, semi-rigid, flexible

**What do learners need to learn?**

Use tools and equipment correctly, to cut ductwork when necessary.

**Skills**
MC1
4.14 Join ductwork using mechanical **techniques**.

**Range:**

**Techniques** – frames, slip joints

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use methods to join ductwork sections together. Two main methods are frame connections and slip joint connections. Frame connections use jointing flanges and gaskets. Slip joint connections use an insertion and overlap method, fixed with screws or rivets. The insertion direction should be the same as the airflow direction.</td>
<td>MC1</td>
</tr>
</tbody>
</table>

4.15 Disassemble parts of a system.

<table>
<thead>
<tr>
<th>What do learners need to learn?</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Access ductwork sections for their removal (rigid, semi-rigid and flexible ductwork sections). Follow disassembling procedures by completing isolation of system/system part before disassembly. Use suitable access equipment where necessary.</td>
<td></td>
</tr>
</tbody>
</table>

4.16 Reinstall **components** within a system.

**Range:**

**Components** - ductwork sections, supply and extract grilles, fan motor casings, fan blades, filters and dampers

<table>
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<tr>
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<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access ductwork components for their replacement (re-installation). Re-install components in a ventilation system. Use suitable access equipment where necessary.</td>
<td></td>
</tr>
</tbody>
</table>
Ventilation

Links to Core Skills

As part of delivery of the skills and knowledge within this specialism reference should be made to criteria that support the development of the four core skills – communication, working collaboratively, problem solving and research. Some examples of criteria that may be linked to supporting these core skills include;

- Communication e.g. providing information and advice to customers and / or wider stakeholders on the potential risks of a change to an industrial system, or making a presentation to a stakeholder on the implications of change

  **Example criteria**
  - 4.7 will support a learner’s personal development in how to communicate with others by using open questioning and listening techniques during discussions with clients regarding effectiveness and efficient status of the installation.

- Work collaboratively with other team members and stakeholders e.g. to develop content to bid for a construction project

  **Example criteria**
  - 4.4 will support a learner’s personal development in how to work collaboratively by communicating and planning with other trades and clients to minimise downtime when carrying out maintenance work.

- Applying a logical approach to solving problems, identifying issues and proposing solutions e.g. through setting criteria for successful implementation of a system, using cost / benefit analysis of the introduction of new procedures or equipment

  **Example criteria**
  - 4.11 will support a learner’s personal development in how to apply a logical approach to solving problems by using fault finding techniques to rectify faults and repair system operation.

- Primary research e.g. obtaining measurements related to a design and / or customer requirements.

  **Example criteria**
  - 2.2/2.3/2.4 will support a learner’s personal development in how to research and interpret information in order to install ventilation systems. Using specifications and plan layout drawings to identify ductwork routes and location of components.

Guidance for delivery

- Opportunities for efficiencies in delivery
- Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery
- Considerations for innovative methods of delivery to include blended learning and other forms of technology,
- Innovative methods of delivery could include:
  - Blended learning throughout theory and practical to contextualise learning – using measurements and calculations (room dimensions and volume, room type, estimated occupancy, air supply and/or extract requirements, fan size, duct size and grille size)
  - Natural ventilation - survey work for openable windows for cross flow, single sided or stack natural ventilation.
Use different rooms in a building for questioning i.e. – would this room be suitable for natural ventilation?
Comparison of calculated data to actual data (measured)
CIBSE guide B – why would different building types have different ventilation requirements? (group debates/discussions)

- **Formative assessment** – oral Q&A, SmartScreen worksheets (samples available)
  - observation of measuring activities
    - Practical - Use of pre-set formative assessments carry out tasks and record on standardised form.
    - Knowledge – pre-set paper-based activity to confirm skills and understanding.
      Learners can use variety of methods to carry out activities, calculators, apps, office IT
- **Ways of ensuring content is delivered in line with current, up to date industry practice**
  - Centres will need to ensure a realistic representation of ventilation systems and components
  - Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
  - The provision must represent the type of equipment currently available in the UK ventilation industry
  - New and emerging ventilation systems, tools, components and technology should be included in delivery e.g. MVHR Mechanical Ventilation with Heat Recovery

### Suggested learning resources

**Books/documents**
- BSRIA the illustrated guide to ventilation
- CIBSE Natural Ventilation AM10
- CIBSE Mixed Mode Ventilation AM13
- CIBSE Guide B Heating, ventilating, air conditioning and refrigeration
- CIBSE Guide F Energy efficiency in buildings
- Building Regulations App Doc F - Building Regulations App Doc F
- BSRIA guide – The rules of thumb (BG9)

**Websites**
- Vent Axia [https://www.vent-axia.com/](https://www.vent-axia.com/)
- Monsoon [https://www.nationalventilation.co.uk/](https://www.nationalventilation.co.uk/)
- [www.air-source.net](http://www.air-source.net)
- [www.bsria.co.uk](http://www.bsria.co.uk)
- [www.CIBSE.org](http://www.CIBSE.org)
- [www.barkell.co.uk](http://www.barkell.co.uk)
- [www.ke-fibretec.com](http://www.ke-fibretec.com)
Appendix 1  Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the Centres and Training Providers homepage on www.cityandguilds.com.

City & Guilds Centre Manual
This document provides guidance for organisations wishing to become City & Guilds approved centres, as well as information for approved centres delivering City & Guilds qualifications. It covers the centre and qualification approval process as well as providing guidance on delivery, assessment and quality assurance for approved centres.

It also details the City & Guilds requirements for ongoing centre and qualification approval, and provides examples of best practice for centres. Specifically, the document includes sections on:

- the centre and qualification approval process
- assessment, internal quality assurance and examination roles at the centre
- registration and certification of candidates
- non-compliance and malpractice
- complaints and appeals
- equal opportunities
- data protection
- management systems
- maintaining records
- internal quality assurance
- external quality assurance.

Our Quality Assurance Requirements
This document explains the requirements for the delivery, assessment and awarding of our qualifications. All centres working with City & Guilds must adopt and implement these requirements across all of their qualification provision. Specifically, this document:

- specifies the quality assurance and control requirements that apply to all centres
- sets out the basis for securing high standards, for all our qualifications and/or assessments
- details the impact on centres of non-compliance

Our Quality Assurance Requirements document encompasses the relevant regulatory requirements of the following documents, which apply to centres working with City & Guilds:

- Ofqual’s General Conditions of Recognition

The centre homepage section of the City & Guilds website also contains useful information on

- Walled Garden: how to register and certificate candidates on line
- Events: dates and information on the latest Centre events
- Online assessment: how to register for e-assessments.
### Useful contacts

<table>
<thead>
<tr>
<th><strong>UK learners</strong></th>
<th>General qualification information</th>
<th>E: <a href="mailto:learnersupport@cityandguilds.com">learnersupport@cityandguilds.com</a></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>International learners</strong></td>
<td>General qualification information</td>
<td>E: <a href="mailto:intcg@cityandguilds.com">intcg@cityandguilds.com</a></td>
</tr>
<tr>
<td><strong>Centres</strong></td>
<td>Exam entries, Certificates, Registrations/enrolment, Invoices, Missing or late exam materials, Nominal roll reports, Results</td>
<td>E: <a href="mailto:centresupport@cityandguilds.com">centresupport@cityandguilds.com</a></td>
</tr>
<tr>
<td><strong>Single subject qualifications</strong></td>
<td>Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change</td>
<td>E: <a href="mailto:singlesubjects@cityandguilds.com">singlesubjects@cityandguilds.com</a></td>
</tr>
<tr>
<td><strong>International awards</strong></td>
<td>Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports</td>
<td>E: <a href="mailto:intops@cityandguilds.com">intops@cityandguilds.com</a></td>
</tr>
<tr>
<td><strong>Walled Garden</strong></td>
<td>Re-issue of password or username, Technical problems, Entries, Results, e-assessment, Navigation, User/menu option, Problems</td>
<td>E: <a href="mailto:walledgarden@cityandguilds.com">walledgarden@cityandguilds.com</a></td>
</tr>
<tr>
<td><strong>Employer</strong></td>
<td>Employer solutions, Mapping, Accreditation, Development Skills, Consultancy</td>
<td>T: +44 (0)121 503 8993 E: <a href="mailto:business@cityandguilds.com">business@cityandguilds.com</a></td>
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</tbody>
</table>

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If you have a complaint, or any suggestions for improvement about any of the services that we provide, email: feedbackandcomplaints@cityandguilds.com
About City & Guilds
As the UK’s leading vocational education organisation, City & Guilds is leading the talent revolution by inspiring people to unlock their potential and develop their skills. City & Guilds is recognised and respected by employers across the world as a sign of quality and exceptional training.

City & Guilds Group
The City & Guilds Group operates from three major hubs: London (servicing Europe, the Caribbean and Americas), Johannesburg (servicing Africa), and Singapore (servicing Asia, Australia and New Zealand). The Group also includes the Institute of Leadership & Management (management and leadership qualifications), City & Guilds Licence to Practice (land-based qualifications) and Learning Assistant (an online e-portfolio).

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