T Level Technical Qualification in

Building Services Engineering for Construction

SPECIFICATION

Teaching from September 2025

610/5780/0

Qualification Information

Qualification Title	T Level Technical Qualification in Building Services Engineering for Construction
T Level Route	Construction
T Level Pathway	Building Services Engineering
Qualification objectives	1. Preparing Learners to progress to a qualification in the same subject area but at a higher level or requiring more specific knowledge, skills and understanding. 2. Preparing Learners for employment
Age group approved	16+
Teaching from	September 2025
Certification from	Summer 2027
Entry requirements	Formal entry requirements are not set by WJEC Eduqas. However, it is expected that Learners have the appropriate attainment at Level 2 before commencing their studies.
Assessment methods	Core – knowledge tests are externally assessed. Core – employer-set project is externally assessed. Occupational specialisms are internally assessed and externally moderated.
Key documents	

Qualification codes	
Ofqual QN	610/5780/0

Version Table

Version and date	Detail	Section
1.0 19/05/2025	First Introduction	N/A
Our specifications may change over time. WJEC Eduqas will inform centres of any amendments and the most up to date version of the specification will always be on the WJEC Eduqas website.		

Contents

1. Introduction

Introduction to T Levels

T Levels are designed to equip learners with the technical knowledge and practical skills necessary for a wide range of careers. Developed in collaboration with industry experts, T Levels offer a rigorous alternative to A Levels, focusing on preparing learners for work, further study or apprenticeships. Each T Level is equivalent to three A Levels and combines classroom learning with industry placements. T Levels are available in a variety of sectors, including health, digital, construction and education.

Introduction to the T Level in Building Services Engineering for Construction

The T Level in Building Services Engineering for Construction is designed to provide students with the knowledge, skills and practical experience required to pursue a career in the building services engineering sector. Combining technical theory with hands-on experience, the course includes substantial industry placements, offering learners the opportunity to apply their learning in real-world environments. The Building Services Engineering T Level prepares learners for a range of roles within the construction and engineering industries, supporting progression into skilled employment, apprenticeships or further study.

T Level Structure

To achieve the T Level learners must meet all requirements of the T Level framework of which the technical qualification is one part. Learners must successfully complete an industry placement, and any other requirements set by the Institute for Apprenticeships and Technical Education such as license to practice qualifications.

Supplementary Requirement for Building Services Engineering for Construction

Providers offering the **Refrigeration Engineering and Air Conditioning Engineering** Occupational Specialism should familiarise themselves with the Supplementary Requirement related to this specialism. Providers should consider offering the Category 1 F-Gas Certificate to T Level learners before learners undertake their Industry Placement, in order to allow the widest possible choice of placement.

Technical Qualification structure

The technical qualification is made up of two components, both of which need to be successfully achieved to attain the T Level Technical Qualification Building Services Engineering for Construction.

The Core Component

The core content is designed to offer sufficient breadth of knowledge and skills for the learner 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 will give a learner a broad understanding of the industry and job roles. At the same time, it will develop 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. (See page 40 of specification for further information).

To achieve the T Level Technical Qualification in Building Services Engineering for Construction learners must achieve:
- the Building Services Engineering Core, plus either
- **one** standalone occupational specialism component, or
- **two** combined occupational specialisms, as specified below.

Mandatory			
Component code	**Component title**	**GLH**	**TQT**
D913Q0	Building Services Engineering Core	520	650

Occupational specialisms: Learners must complete one standalone or one combination			
Component code	**Component title**	**GLH**	**TQT**
Standalone			
D9A3Q0	Electrotechnical engineering	650	820
D9B3Q0	Protection systems engineering	570	720
D9C3Q0	Gas engineering	650	735
D9D3Q0	Plumbing & Heating engineering	670	780
Combinations			
D9E3Q0	Air conditioning engineering	700	850
D9F3Q0	Refrigeration engineering		

Qualification size

The size of the T Level Technical Qualification in Building Services Engineering for Construction is expressed in terms of guided learning hours and total qualification time.

Guided learning hours (GLH) means activities such as classroom-based learning, tutorials and online learning, which are directly supervised by a teacher, tutor or invigilator. It also includes all forms of assessment which take place under the immediate guidance or supervision of a teacher, supervisor or invigilator.

Guided learning hours are allocated per component to support centre planning and delivery. Teachers may choose to deliver this qualification holistically and, therefore, guided learning hours per component are provided as a recommendation only.

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 the guided learning hours and/or supervised assessment (GLH) and additional time spent in preparation, study and some formative assessment activities.

Resource requirements

Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualification before designing a course programme.

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 learning or 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.

Centres must 'Recruit learners with integrity', adhering to the guidelines set out in the JCQ Access Arrangements and Reasonable Adjustments Document. Further details on this can be found in section 2 of this document.

Centre staffing

Staff delivering and assessing these qualifications must be able to demonstrate that they meet the following requirements:
- be occupationally competent and qualified at or above the level they are delivering
- have Maths and English at Level 2
- 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
- have experience or training in the following to support the delivery of this technical qualification:
  - delivering project-based qualifications

- preparation for exam-based assessments.

BSE core

Staff who are familiar with Level 3 Construction/BSE qualifications will be able to teach the core subjects.

Occupational specialisms specific requirements

Staff assessing the occupational specialisms must meet the specific requirements per specialism as noted below and hold or be working towards a relevant recognised assessor qualification such as a Level 3 Certificate in Assessing Vocational Achievement and continue to practise to that standard. Assessors who hold earlier qualifications (D32, D33 or TQFE/TQSE) should have CPD evidence that meets current standards. Assessors must also hold a relevant trade qualification and/or have registration with a relevant trade organisation as 'Approved Tradesperson' or have 'Eng-Tech' status.

Electrotechnical engineering
Hold an NVQ Level 3 in Electrical Installations or equivalent qualification, with the addition of AM2 competency for the practical delivery **or** have current JIB or ECS Gold card registration.

Gas engineering
Hold a Level 3 Diploma in Gas Utilisation or equivalent qualification including relevant CPD that demonstrates the qualification standards and requirements.

Protection systems engineering
Hold an NVQ Level 3 in Electronic Security and Emergency systems or a suitable Level 3 Electrical or Electronic engineering qualification or equivalent qualification. Relevant CPD that demonstrates experience of working with the range of electronic security systems included in this qualification.

Plumbing and Heating
Hold an NVQ Level 3 in Plumbing and Heating Engineering or equivalent qualification including relevant CPD that demonstrates the qualification standards and requirements.

Air conditioning and refrigeration engineering
Hold a relevant NVQ Level 3 Air conditioning or Refrigeration engineering qualification or industry experience of a minimum of five years. Must hold an F-Gas qualification.

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.

Electrotechnical engineering:
- **Hand tools:** rules, levels, gauges, plumb lines, cable cutters, screwdrivers, wire strippers, knives, files, wrenches, hammers, saws, data cable crimping tools, insulation displacement tools, reamers
- **Power tools:** hammer drills, pillar drills, electric screwdrivers, soldering irons
- **Equipment:** testing/commissioning equipment, conduit benders, tray benders, bending springs, MI kit, stocks and dies, bench vices
- **Electrical test equipment:** multifunctional test meters (including test accessories, e.g. socket outlet adapters), approved voltage indicator, proving unit/check box, network tester and isolation kits, clamp-on ammeter, voltage meter

- Standard test rigs in accordance with the latest Assessor Guide for Test Rigs document
- Rubber matting for live testing, unless risk assessment is carried out to mitigate
- At least one clean copy of the current version of the following, per test rig: BS:7671, IET On-Site Guide and IET Guidance Note 3.

Protection systems engineering:

- **Hand tools:** rules, levels, cable cutters, wire cutters, pliers, screwdrivers, wire strippers, knives, files, wrenches, hammers, saws, RJ45 and BNC crimping tools, insulation displacement tools
- **Power tools:** SDS/hammer drills, combi drills, electric screwdrivers
- **Electrical test equipment:** digital multimeter, 230 V AC voltage indicator and proving unit (with lock off kit), RF signal strength meter, network cable tester, insulation resistance tester, smoke hoods, smoke cannisters, testing/commissioning equipment, programming devices, programming software
- **Materials:** range of cables (to include: 8-core 0.22 mm2 alarm, FP200, RG-59 co-axial, CAT5e), RJ-45 sockets and plugs, RG-59 BNC crimp connectors, conduit, trunking, basket and tray
- **System components:** range of system components complete with manufacturers' data sheets (the type of system covered will vary with each assessment version – see current assessor pack for detailed component requirements)
- Suitable access equipment for the location
- Personal protective equipment (PPE)
- Each installation bay must have a pre-installed 13 A electrical supply (including emergency stop button provision)
- Appropriate waste disposal and recycling facilities.

Air conditioning and Refrigeration engineering:

- Specialist refrigeration tools (tube cutters, pipe benders, swaging tools, etc.)
- Suitable refrigeration-grade soft-rolled copper pipe and electrical cable
- Brazing equipment and consumables
- Nitrogen pressure testing and purging equipment
- Vacuum pump and vacuum gauge
- Refrigerant and charging equipment
- Test equipment (multimeter, thermometers, etc.)
- PPE
- Manufacturer’s instructions for all equipment must be available
- Condensing units and matched coolers
- 2–3 kW split heat pump systems
- Cold room of 6 m^3 minimum and suitable for -20°C operation
- Access equipment (ladders, work platforms etc.)
- Manual and / or mechanical handling and lifting equipment (to lift and move loads e.g. systems and units)

Plumbing and heating engineering:

- **General plumbing and heating tools:** screwdrivers, power drills, hammers, chisels, water pump pliers, adjustable wrench, adjustable spanners, spirit levels, manual pipe threaders, pipe cutters (plastic and copper), hand saws, pliers, circlip pliers, plungers, tap reseating tools, drain augers, drain rods, pressure gauges, flow cups, thermometers, bending tools, blowtorches (soldering equipment, pipe benders, adjustable spanners, etc.)
- **Specialist plumbing and heating tools:** hydraulic machine benders, hydraulic crimping kits, hydraulic pressure testers, circular saws, jig saws, reciprocating saws, multi-tool, press fit gun, portable pipe freezing kits

- Electrical safe isolation kits
- Suitable access equipment for the location
- PPE
- **Sanitary appliances:** WCs (high and low level, closed coupled), standard baths, standard shower trays, wall-mounted basins, pedestal basins, appliance traps, Document M compliant sanitaryware
- **Rainwater system components:** half round, square, ogee, high capacity
- **Measuring equipment**: tape measures, laser measures, digital measuring equipment
- **Commissioning equipment:** cold water, hot water, sanitation, rainwater, central heating
- **Operational plumbing systems:** direct and indirect cold water, boosted cold water, hot water, above-ground drainage, below-ground drainage, rainwater harvesting, rainwater systems, grey water re-use, unvented hot water cylinder
- **Plumbing components:** sink taps (mixer and pillar), wash hand basin taps (mixer, pillar and infrared), drain valves, float operated valves, shower mixer valves (exposed), electric showers, siphon/drop valves, service valves, supply stop valves, blending valves, check valves, air admittance valves, line strainers, control components, safety components, solenoid valves, unvented hot water cylinders, macerators, accumulators, expansion vessels
- Each **plumbing** installation bay must have a pre-installed working hot and cold-water supply, suitable drainage point and 13 A electrical supply (including emergency stop button provision)
- **Operational heating systems:** fully pumped, 3x two-port valves (S-Plan Plus)
- **Heat-emitting devices:** radiators (towel, panel, low surface temperature), underfloor heating
- **Heating components:** safety controls, diverter valves, automatic air vents, circulating pumps manual radiator valves (lockshield and wheel head), filling loops, thermostatic radiator valves, zone valves, automatic bypass valves, expansion vessels, central heating pumps, pressure/temperature relief valves, corrosion filters (magnetic filters), underfloor heating manifolds
- **Heating controls:** timing devices – clocks and programmers, room thermostats, programmable room thermostat, optimiser, hot water thermostats, frost thermostats, smart controls
- Each **heating** installation bay must have a suitable pre-installed boiler and cylinder (if applicable). It must also contain a pre-installed hot and cold-water supply to a suitable appliance such as a WHB/sink, pre-installed 13 A electrical supply (including emergency stop button provision), suitable drainage point, suitable flue gas extraction provision and a carbon monoxide detector/alarm
- **Plumbing and heating:** Building information management software to allow updating of basic data as part of a planning review
- Appropriate waste disposal and recycling facilities.

Gas engineering:

- **General gas engineering tools:** pressure gauges, screwdrivers, hammers, wood chisels, water pump pliers, spanners, spirit levels, manual pipe threading machines, pipe cutters, pipe slices, hand saws, bending machines, bending springs, blowtorches, drills, temporary continuity bonds
- **Specialist gas equipment:** pressure gauges, combustion performance analysers gas leak detectors
- **Gas components:** multi-functional control valves/gas valves, diverter valves, fan, burners, pumps, plate to plate heat exchangers, main heat exchangers, pressure relief valves, automatic air vents, printed circuit boards, air pressure switches, combustion

- thermostats, injectors, emergency control valves (ECVs), flame supervision devices, under pressure shut off valves (UPSO), over pressure shut off valves (OPSO), safety shut off valves (SSOV)
- **Heating controls:** (thermostats, zone valves, etc) programmers, room thermostats, cylinder thermostats
- **Gas meters (including regulators):** smart meters, pre-payment meters, U6, E6
- **Measuring equipment:** tape measures, laser measures, digital manometer and water gauge
- PPE
- Electrical safe isolation kits
- Suitable access equipment for the location
- **Flueless (type A) gas appliances:** free-standing gas cookers, gas hobs
- **Open-flued (type B) appliances:** space heaters (fires)
- **Room-sealed (type C) gas appliances:** water heaters and gas boilers
- Gas components (fans, thermistors, etc.)
- **Ventilators:** range of ventilators suitable for gas appliances, including simulated area to allow the installation (cavity walls, high level, low level)
- **Natural gas (NG) system:** Each installation bay must have a pre-installed gas supply, including emergency control valve. It must also contain a pre-installed hot and cold-water supply to a suitable appliance such as a WHB/sink, pre-installed 13 A electrical supply (including emergency stop button provision), suitable drainage point, suitable flue gas extraction provision and a carbon monoxide detector/alarm
- Building information management software to allow updating of basic data as part of a planning review
- Appropriate waste disposal and recycling facilities
- **Liquefied petroleum gas (LPG) system:** Each installation bay must have a pre-installed changeover valve, under pressure shut off valves (UPSO), over pressure shut off valves (OPSO), safety shut off valves (SSOV), emergency control valve and LPG gas bottles. It must also contain a pre-installed hot and cold-water supply to a suitable appliance such as a WHB/sink, pre-installed 13 A electrical supply (including emergency stop button provision), suitable drainage point, suitable flue gas extraction provision and a carbon monoxide detector/alarm.

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 are met when registering for this qualification.

Formal entry requirements are not set by WJEC Eduqas, but it is expected that learners will 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, e.g. construction and the built environment.

2. Delivering the qualification

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.

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

Recruiting learners with integrity

As laid out in the **JCQ Access Arrangements and Reasonable Adjustments** document, it is vital that centres recruit with integrity with regard to vocational qualifications. Centres must ensure that learners have the correct information and advice on their selected qualification(s) and that the qualification(s) will meet their needs. The recruitment process must include the centre assessing each potential learner. The centre must make justifiable and professional judgements about the learner's potential to successfully complete the assessment and achieve the qualification. Such an assessment must identify, where appropriate, the support that will be made available to the learner to facilitate access to the qualification(s).

Where the recruitment process identifies that the learner may not be able to demonstrate Attainment, and thus gain achievement in all assessments for the selected qualification, this must be communicated clearly in writing to the learner. A learner may still decide to proceed with a qualification and not be entered for all or some of the assessments.

Centres must ensure that learners are aware of:

- the range of options available, including any reasonable adjustments that may be necessary, to enable the demonstration of attainment across all the required assessments
- any restrictions on progression routes to the learner because of not achieving certain outcomes.

Programme delivery

The technical qualification should be delivered through approaches that meet the needs of learners. WJEC Eduqas recommends using a variety of delivery methods, including in 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.

Transfer of attainment

We fully expect some students to switch between T Levels, particularly in the early weeks, as happens currently with many post-16 courses. Some providers may co-teach some T Level groups for some classes where these are within the same route and where much of the core content is the same. This may well result in students switching to a different T Level, as they discover more about the content, including the range of occupational specialisms. Depending on the point at which a student switches, they may need some additional support to catch up with any other pathway-specific learning they have missed. During Year 1, providers should consider the degree of overlap between two T Levels, and the remaining time pre-assessment, to determine which transfers should be permitted. For funding purposes, it is important that students have made a decision about their T Level and registered for their occupational specialism by the end of the first year. However, once an assessment has been taken switching may become more difficult. T Level core assessments will vary in terms of content coverage, duration and method, and therefore attainment from one T Level cannot count towards another.

Use of language

As our understanding of diversity, equity and inclusion evolves, so must our language. Updated terminology better reflects individual identities and fosters respect and accuracy. Language used should be specific as possible. Staying informed and adaptable is crucial, as inclusive language promotes dignity and equity. Recognising that language will continue to evolve, we will remain open to further amendments to ensure it accurately represents and supports all individuals. WJEC Eduqas will inform centres of any amendments and the most up to date version of the specification will always be on the website.

Competency frameworks

The technical qualification has been developed to include competency frameworks for T Levels, which demonstrate an array of competencies across Maths, English and digital skills as well as four key core skills that have been mapped onto 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 following core skills are fundamental in the development of the required knowledge, skills and behaviours that learners will need to use when they progress onwards from completing their T Level. These core skills have been mapped onto the design of the qualification content and developed in consultation with the industry and providers. The mapping identifies 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:
  - Advantages 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 systems of works
  - Key stages of the design process

- Different types of sustainable solutions listed in the range, and how they are used to inform the building process
- Different insulation materials, controls and building monitoring systems (BMS) used to improve energy efficiency in buildings
- Use of both manufacturer instructions and technical guidance to solve problems
- Complying with data storage requirements in relation to security and protection
- 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
- Use of digital engineering techniques in the construction industry and where to apply them
- Utilising benchmarking, KPIs and target setting when measuring business success
- Ensuring key requirements of the 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:
  - Collecting information on BSE systems
  - Researching the various components that make up BSE 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
  - Structure of the construction industry, including business types
  - Role and importance of CPD
  - Sustainable construction solutions
  - Researching the techniques aimed at maximising value and minimising waste within the industry
  - Researching the requirements of current UK building regulations to ensure compliance
  - 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
  - Using current UK and international standards (BS EN).

- **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:
  - Presenting installation plans to key stakeholders or the client
  - Presenting risk assessments, method statements and safe systems of work to enable safe working
  - Communicating with the end user when safely isolating services/systems
  - Communicating when unsafe situations occur in the workplace following the current HSE reporting requirements
  - Communicating the potential implications of poor design to the different parties affected in the construction chain
  - Explaining the benefits to contractors and the client/customer of profitability and project success, detailing the implications of not having accurate measurements
  - Communicating information and data sources for construction projects
  - Communicating using building information modelling (BIM) and workflow software packages

- Promoting good customer service, providing information and advice to customers
- Implementing change requests from various parties, including clients
- Communicating using technology connected to the internet of things and understanding its 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 understanding constraints on cost and time
- Communicating 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:
  - Taking part in group discussions and presentations, collating information in response to a specification or client brief
  - Following 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 in the supply chain
  - BIM and the effect it has on real-time project delivery and collaboration
  - Working 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
  - 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
  - Working 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 section of each performance criteria.

General English competencies
The general English competencies outline a framework of six general English competencies, 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 competencies, 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 competencies, 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

3. Assessment

Learners must complete:
Two externally set exams covering knowledge from the building services engineering core (component 350).

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

One employer-set project (ESP) covering knowledge and skills from the building services engineering core (component 350).

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

And

One of the following occupational specialisms**:**
Electrotechnical engineering
Protection systems engineering
Gas engineering
Plumbing and heating engineering

Or

A **combination** of air conditioning engineering **and** refrigeration engineering

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 provider's 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.

4. Entry Procedures

Registrations

Learners must be registered for the T Level in Building Services Engineering for Construction in their first year of study and this must be done before the first assessment sitting.

Components and Qualification entry

In year 1 of the qualification, entries for the core external assessment can only be submitted for the June assessment.

After year 1 of the qualification, entries for both Core external examinations papers and the Core ESP can be submitted either for the November or June series during the two years of the course.

Candidates must take both Core external examinations papers in the same series. Candidates can take the Core ESP in the same series or a different series to the Core exams.

Candidates must be entered for an Occupational Specialism before sitting the assessment. Where a candidate is taking a combination of Occupational Specialisms, they will need to be entered separately for both specialisms.

A cash-in entry code must be applied in order to allow for aggregation to occur and an overall grade for the qualification to be awarded.

Resits

Learners who fail either one or both exams in the core component will need to retake both exams and must do so in the same assessment window. Any retake must be completed within two years after the completion of the learner's T level programme.

Learners who fail the employer-set project on first submission can retake in any assessment window. Any retake must be completed within two years after the completion of the learner's T level programme.

Learners who fail the first submission can retake in any assessment window. Any retake must be completed within two years after the completion of the learner's T level programme. In the event a student resits an assessment and achieves a lower mark, the higher mark will be retained.

Learners may also resit a component to improve their score. In this event, they must sit the entire component, e.g. both core exams. This can be done in the following assessment window.

If a learner is resitting the Employer Set Project, or Occupational Specialism, this must be done on the latest assessment brief, not a resit of the same brief. There are no second attempts permitted on the same assessment within the same window.

5. Awarding, grading and reporting

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 to threshold competence. As an example, if a learner decided to take Air conditioning and refrigeration 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.

Technical qualification scheme of assessment overview

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

Assessment component (number)	Method	Duration	Marks	Weighting	Marking	Grading
Exam paper 1 (D913U10-1)	Externally set exam	2.5 hours	110	35%	Externally marked	This component will be awarded on the grade scale A* - E
Exam paper 2 (D913U10-2)	Externally set exam	2.5 hours	110	35%	Externally marked	
Employer-set project (D913U20-1)	Externally set project	17 hours	100	30%	Externally marked	

Occupational Specialism Component – Learners must complete one assessment component from the below

Assessment component (number)	Method	Duration	Marks	Weighting	Marking	Grading
Electrotechnical engineering (D9A3Q0L-1)	Externally set assignment	24 hours	90	100%	Internally assessed and externally moderated	All occupational specialism components will be awarded on the grade scale P, M, D
Plumbing and heating engineering (D9B3Q0L-1)	Externally set assignment	35 hours	90	100%	Internally assessed and externally moderated	
Protection systems engineering (D9C3Q0L-1)	Externally set assignment	15 hours	90	100%	Internally assessed and externally moderated	
Gas engineering (D9D3Q0L-1)	Externally set assignment	24 hours	90	100%	Internally assessed and externally moderated	

Occupational Specialism Component* – Learners must complete both assessment components from one of the combinations below						
Air conditioning and Refrigeration engineering						
Air conditioning engineering (D9E3Q0L-1)	Externally set assignment	28 hours	90	100%	Externally moderated	All occupational specialism components will be awarded on the grade scale P, M, D
Refrigeration engineering (D9F3Q0L-1)	Externally set assignment	28 hours	90	100%	Externally moderated	

Core component scheme of 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) used to promote consistency among qualifications of a similar purpose. They are designed to allow judgement of the learner 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.

AO weightings for the assessment components related to the core components are detailed below.

Core exam

Assessment objective	Description	Weighting
AO1 a Demonstrate knowledge	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 e.g. terminology, number facts etc.	10%
AO1 b Demonstrate understanding	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 e.g. cause and effect.	25%
AO2 Apply knowledge and understanding to different situations and context	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.	45%
AO3 Analyse and evaluate information and issues	Learners will be provided with information e.g. in the form of a detailed scenario requiring them to analyse the interrelated issues arising and evaluate, e.g., 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.	20%

Component	Assessment method	Description and conditions
Core exam	Externally marked tests	These tests are **externally set and externally marked** and will be sat through question papers provided by WJEC Eduqas. These tests are designed to assess learners' 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** Learners who fail either one or both exams in the core component will need to retake both exams and must do so in the same assessment window. Any retake must be completed within two years after the completion of the learner's T level programme.

Component	Assessment method	Assessment overview	Permitted assessment materials
Paper 1	Externally marked tests	These exams will be made up of different question types that include short answer questions, structured questions and extended response questions. The exam paper will consist of part A and part B. Part A will include short and medium answer questions and Part B will include longer form questions. The level of difficulty will increase through the paper with lower demand questions at the beginning to higher demand questions at the end of the paper. The level of demand will increase through the paper with lower demand questions at the beginning of the question paper to higher demand questions at the end of the question paper. Content overview: • Health and safety in construction • Construction design principles • Construction and the built environment industry • Construction sustainability principles • Building technology principles • Tools, equipment and materials	Pen with blue or black ink Non-programmable calculator

Component	Assessment method	Assessment overview	Permitted assessment materials
Paper 2	Externally marked tests	These exams will be made up of different question types that include short answer questions, structured questions and extended response questions. The exam paper will consist of part A and part B. Part A will include short and medium answer questions and Part B will include longer form questions. The level of demand will increase through the paper with lower demand questions at the beginning of the question paper to higher demand questions at the end of the question paper. Content overview: • Construction science principles • Construction measurement principles • Construction information and data principles • Relationship management in construction • Digital technology in construction • Construction commercial/business principles • Building Services Engineering (BSE) systems • Maintenance principles	Pen with blue or black ink Non-programmable calculator

Both core exams will follow the same structure but each core exams covers different technical content. Each exam paper is made up of two parts:

- Part A (70%)

and

- Part B (30%)

Employer-set project

Assessment objective	Typical evidence	Approximate weighting
AO1 Planning skills and strategies	• 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.	14%
AO2 Apply knowledge and skills to the context of the project	• relevant core knowledge applied to respond to brief • references relevant legislation, building controls, materials, concepts, waste disposal and site access considerations.	54%
AO3 Select relevant techniques and resources to meet the brief	• selection of techniques and resources in order to support a response to the brief; consideration of the techniques and resources that are most effective and appropriate to use, and accurate and informed use of these.	10%
AO4 Use Maths, English and digital skills	• use of correct terminology, abbreviations, units of measurement in context • consideration of audience of brief response (technical versus 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.	16%
AO5 Carry out tasks and evaluate for fitness for purpose	• 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.	6%

Component	Assessment method	Description and conditions
Employer-set project	Externally marked project	This project, developed in collaboration with employers, is **externally set and externally marked** by WJEC Eduqas. It is designed to require the learner 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 content. Projects will be released to centre staff in advance of any of the assessment windows for each task. WJEC Eduqas will provide centres with assessment windows to timetable assessment sessions within, in accordance with the assessment times prescribed in the employer-set project centre guidance. 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. Learners who fail the employer-set project on first submission can retake in any assessment window. Any retake must be completed within two years after the completion of the learner's T level programme.

Component	Assessment Method	Assessment overview
Employer-set project	Externally marked project	**Content overview:** The employer-set project samples knowledge drawn from across the core content in relation to the specific project version context – however, due to their importance **all** versions of the employer-set project will cover content from the following core underpinning knowledge outcomes: • Health and safety • Construction design principles • Sustainability principles • Building services engineering (BSE) systems. **Assessment overview:** The employer-set project is an assessment made up of several tasks that will take place within controlled conditions, assessing the knowledge and skills learnt as part of the core element of the T Level. Each project will be developed together with employers in the industry to reflect realistic types of developments, activities and challenges. The project is made up of a number of tasks which all relate to the same employer-set project brief and tender specification. • 1.1 – Research • 1.2 – Report • 1.3 – Project plan • 1.4 – Presentation • 2.1 – Collaborative problem-solving • 2.2 – Evaluation The project only draws on the content from the common core knowledge that sits across all specialisms for BSE (specific knowledge and skills for each specialism will be assessed in the practical assignments). The project is linked to the core skills: • Problem solving • Research • Communication • Working collaboratively with others.

Core grading

The T Levels Technical Qualification (TQ) in Building Services Engineering for Construction Core is made up of the below sub-components (and weightings).

- Exam (70%)
- Employer-Set Project (30%)

Uniform Mark Scale (UMS) grade boundaries

The table below shows the UMS (Uniform Mark Scale) values available for grades in the sub-components. It also shows the UMS values required to achieve each grade for the overall Core. This table will not vary across the series, the values are fixed for this TQ.

Grade boundary	Exam sub-component	ESP sub-component	Overall Core
A*	252 – 280	108 – 120	360 – 400
A	224 – 251	96 – 107	320 – 359
B	196 – 223	84 – 95	280 – 319
C	168 – 195	72 – 83	240 – 279
D	140 – 167	60 – 71	200 – 239
E	112 – 139	48 – 59	160 – 199
Unclassified (U)	0 – 111	0 – 47	0 – 159

Scheduling of the Employer-set project assessments

The employer-set project assessment window will occur from March to May annually. Specific dates will be released annually through the key date schedule for the following academic year.

Task	Scheduling	Task duration
1.1	WJEC Eduqas sets the assessment window for the centre to timetable	3 hours
1.2	WJEC Eduqas sets the assessment window for the centre to timetable	6 hours
1.3	WJEC Eduqas sets the assessment window for the centre to timetable	3 hours
1.4	WJEC Eduqas sets the assessment window for the centre to timetable	2 hours
2.1	WJEC Eduqas sets the assessment window for the centre to timetable	2 hours
2.2	WJEC Eduqas sets the assessment window for the centre to timetable	1 hour

Occupational specialism component scheme of assessment

What is the occupational specialism component?

The occupational specialism assignment consists of a project brief presented as client requirements or a specification of work that is realistic to the occupational specialism, rather than detailed instructions on what to do, to allow the learner to demonstrate that they have the knowledge required to implement the brief. There will be several high-level tasks in every version of the assessment and these will take the form of planning, installing, service and maintenance. Within each high-level task there will be several sub-tasks that learners will need to complete as directed within the assessment documents. The sub-tasks will reflect the project brief for that version of the assignment.

How is the occupational specialism component marked?

Occupational specialism assessments will be set and marked at task level.

Tasks within the occupational specialisms are broken down into smaller themes. The assessment themes are broad thematic focuses to ensure that all the performance criteria across the specialism are assessed, supporting reliability of the assessment. These themes include:

- health and safety
- design and planning
- systems and components
- reports and information
- inspecting and testing of systems and components
- handover and communication
- working with faults.

Each task includes a sample of these themes, and each learner will receive a total mark for each assessment theme. The total for each assessment theme is accumulated, giving a total mark for the assessment. Assessment themes will be common across every version of the assessment and will assess a similar range of evidence across assessment versions, ensuring comparability of demand between every version of the assessment.

Although evidence from across all tasks can be used to demonstrate performance against an assessment theme, internal markers will be directed to specific task evidence that must be used to support judgements on performance against the assessment theme. The assessment themes will be broad enough to ensure that all the performance criteria across the specialism are assessed, supporting reliability of the assessment.

In order to ensure reliability, and consistent and accurate judgements on performance, assessment themes may consist of sub-assessment themes due to the potentially wide content coverage and to ensure that the performance outcome is assessed to the appropriate depth and breadth. This still allows for the appropriate base mark to be applied to the assessment theme but also ensures that the distribution of marks within and across bands is more manageable and increases the reliability of judgements made and marks awarded. Internal assessors will give an appropriate mark in relation to the learner's performance for each individual sub-assessment theme, but this will contribute to the overall mark for that assessment theme. Internal assessors will then need to evidence the decision for the mark awarded for each assessment theme on the Candidate Record Form (CRF).

Component	Assessment method	Overview and conditions
Occupational specialism assignment	Externally set, externally moderated	This assessment is **externally set, internally marked and externally moderated**, and is designed to require the learner to identify and use effectively, in an integrated way, an appropriate selection of skills, techniques, concepts, theories and knowledge from across the occupational area. The assessment brief will be released two weeks ahead of the assessment window starting to allow centres suitable time to prepare for the assessment window. The exact date will depend on the specific dates for the assessment window, which will be outlined within the key dates schedule released to centres. Centres will be required to maintain the security of all live assessment materials until assessment windows are open. Assessments 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 assessments in advance. The marking grid for the assessment will be available to centres from the start of the learning programme. Learners who fail the occupational specialism following the first submission can retake in any assessment window. Any retake must be completed within two years after the completion of the learner's T level programme. Please note that for externally set assessments WJEC Eduqas provides guidance and support to centres on the marking process and associated marking grid in the assessment pack for the qualification, and guidance on the use of marking grids.

Electrotechnical engineering	Externally set, externally moderated	**Content overview** Learners will be able to: • Install electrotechnical systems • Commission electrotechnical systems • Maintain electrotechnical systems • Decommission electrotechnical systems. **Assessment overview** Learners will be assessed against the following assessment themes: • Health and Safety • Design and planning • Systems and components • Inspect and test systems and components • Report and information • Handover and communication • Working with faults.
Gas engineering	Externally set, externally moderated	**Content overview** Learners will be able to: • Install gas systems • Commission gas systems • Maintain gas systems • Decommission gas systems. **Assessment overview** Learners will be assessed against the following assessment themes: • Health and Safety • Design and planning • Systems and components • Inspect and test systems and components • Report and information • Handover and communication • Working with faults.
Protection systems engineering	Externally set, externally moderated	**Content overview** Learners will be able to: • Install protection systems • Commission protection systems • Maintain protection systems • Decommission protection systems. **Assessment overview** Learners will be assessed against the following assessment themes: • Health and Safety • Design and planning • Systems and components • Inspect and test systems and components • Report and information • Handover and communication • Working with faults.

Plumbing and heating engineering	Externally set, externally moderated	**Content overview** Learners will be able to: • Install plumbing and heating systems • Commission plumbing and heating systems • Maintain plumbing and heating systems • Decommission plumbing and heating systems. **Assessment overview** Learners will be assessed against the following assessment themes: • Health and Safety • Design and planning • Systems and components • Inspect and test systems and components • Report and information • Handover and communication • Working with faults.
Air conditioning engineering	Externally set, externally moderated	**Content overview** Learners will be able to: • Install air conditioning systems • Maintain air conditioning systems • Commission air conditioning systems. **Assessment overview** Learners will be assessed against the following assessment themes: • Health and Safety • Design and planning • Systems and components • Inspect and test systems and components • Report and information • Handover and communication • Working with faults.
Refrigeration engineering	Externally set, externally moderated	**Content overview** Learners will be able to: • Install refrigeration systems • Maintain refrigeration systems • Commission refrigeration systems. **Assessment overview** Learners will be assessed against the following assessment themes: • Health and Safety • Design and planning • Systems and components • Inspect and test systems and components • Report and information • Handover and communication • Working with faults.

Availability of assessments

The table below sets out the scheduled assessment windows annually for the T Level in Building Services Engineering for Construction. Exact key dates for assessment that are externally marked (core exams and the employer-set project) will be communicated to approved providers annually through the key date schedule.

Component	Series	Exam type	Calendar Month/s	Assessment window/set date
Core exam 1	Summer series *Autumn series	Written exam Written exam	June November	Set date/time Set date/time
Core exam 2	Summer series *Autumn series	Written exam Written exam	June November	Set date/time Set date/time
Employer-set project	Summer series *Autumn series	Project Project	April - May October-November	Assessment window Assessment window
Occupational specialism	One series annually	Assignment	February – May (first assessment 2026)	Assessment window

6. Technical qualification grading and result reporting

Awarding the technical qualification grade

The technical qualification components are awarded as shown below:

Component	Grading
Core	A* - E
Occupational specialism	Pass, Merit and Distinction

Core component

The overall grade of the core component is calculated using the aggregation of points from across all core assessment components.

Core component grade descriptors

Component	Grade	Descriptor
Core	A	To achieve an ‘A’ grade a learner will: 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 with 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.

Component	Grade	Descriptor
Core	E	To achieve an 'E' grade a learner will: Demonstrate a limited understanding of 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 evidence based, and that relate 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, which is brief with no reference to how to improve. Learners need to complete all components to be awarded the technical qualification. Any performance determined as not meeting the standard set by WJEC Eduqas will receive an unclassified (U) result.

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Occupational specialism component

Calculation of the grade for the occupational specialism is based on setting grade boundaries for Pass and Distinction. The setting of grade boundaries is based on judgemental evidence, against the grade descriptors for the occupational specialisms, review of the Guide Standard Exemplification Materials (Grade Standard Exemplification Materials after the first award) and review of statistical evidence.

Pass and Distinction grade descriptors can be found in both learner and centre occupational assessment materials.

To successfully achieve an occupational specialism the learner needs to be recognised at threshold competence (Pass).

Threshold competence refers to a level of competence that:

- signifies that a student is well placed to develop full occupational competence, with further support and development, once in employment
- is as close to full occupational competence as can be reasonably expected of a student studying the TQ in a classroom-based setting (for example, in the classroom, workshops, simulated working and (where appropriate) supervised working environments)

- signifies that a student has achieved at least a pass in relation to the relevant occupational specialism component.

If a learner does not meet the minimum standards as determined by WJEC Eduqas for either/both the core component and occupational specialism they will be issued with an unclassified (U) grade.

T Level Grading

To be awarded an overall T Level grade, a student must pass both components of their TQ, successfully, complete an industry placement and meet any other requirements set by the T Level panel within the Institute. T Levels will vary in size, largely dependent on the size of the TQ.

In meeting the above requirements, the learner will be eligible to be awarded an overall grade for the T Level in Building Services Engineering for Construction. The calculation of the grade will be based on performance in the core component and occupational specialism, as set out below:

Calculation of the T Level Grade				
	Occupational specialism grade			
Core component grade	**Grade**	**Distinction**	**Merit**	**Pass**
	A*	Distinction*	Distinction	Distinction
	A	Distinction	Distinction	Merit
	B	Distinction	Merit	Merit
	C	Distinction	Merit	Pass
	D	Merit	Merit	Pass
	E	Merit	Pass	Pass

Component	Overall weighting to T Level grade
Core component grade	50%
Occupational specialism component grade	50%

Students who are required to complete a combination of two occupational specialisms

- Students will still receive separate grades for each specialism, and these will be listed separately on their T Level certificate.
- Students will need to pass both occupational specialisms to pass their T Level overall. A single combined occupational specialism grade will be used to calculate the overall T level grade. The calculation of the overall combined grade for the occupational specialism component will be based on performance in each specialism, as set out in the table below:

Calculation of the T Level Grade (Combination of two occupational specialisms)				
		Occupational Specialism 1		
Occupational Specialism 2		Distinction	Merit	Pass
	Distinction	Distinction	Distinction	Merit
	Merit	Distinction	Merit	Pass
	Pass	Merit	Pass	Pass

7. Administration

Lost candidate work

If candidate work is lost, WJEC Eduqas should be notified immediately of the date of the loss, how it occurred, and who was responsible for the loss. Candidates **may** be eligible for special consideration if:

- The loss is not a consequence of negligence on the part of the candidate.
- The centre is able to verify that the work was completed or partially completed and had been monitored whilst it was in progress.

Centres should notify WJEC Eduqas of the loss by submitting JCQ Form 15 to WJEC Eduqas at **specialrequirements@wjec.co.uk**

Malpractice

For detailed guidance on dealing with suspected malpractice you should refer to the JCQ document *Suspected Malpractice in Examinations and Assessment: Policies and procedures* – https://www.jcq.org.uk/exams-office/malpractice/

Candidates must not, for example:

- Submit work which is not their own.
- Make available their work to other candidates through any medium.
- Allow other candidates to have access to their own independently sourced material.
- Assist other candidates to produce work.
- Use books, the internet or other sources without acknowledgement or attribution.
- Submit work that has been word processed by a third party without acknowledgement.
- Include inappropriate, offensive or obscene material.
- Copy or paraphrase from another source such as an AI tool.

Candidates are not prohibited from lending books or other resources to one another, but they must not plagiarise others' research.

Candidates **must not** post their work on social media. They should be made aware of the JCQ document Information for candidates – Guidelines when referring to examinations/assessments through the Internet – https://www.jcq.org.uk/exams-office/information-for-candidates-documents/

Heads of centre and senior leaders **must** ensure that those members of teaching staff involved in the direct supervision of candidates producing controlled assessment are aware of the potential for malpractice.

Teaching staff must be reminded that failure to report allegations of malpractice or suspected malpractice constitutes malpractice itself.

Teaching staff **must:**

- be vigilant in relation to candidate malpractice and be fully aware of the published regulations
- report any alleged, suspected or actual incidents of malpractice to the senior leadership team or directly to WJEC Eduqas
- ensure candidates sign a candidate declaration form outlining that the final product reflects their own independent work and isn't copied or paraphrased from another source such as an AI tool. See JCQ document Malpractice - JCQ Joint Council for Qualifications for further details.

If a centre suspects malpractice, it should follow the procedures in the table below.

Actual or suspected candidate malpractice identified by the centre **prior** to the candidate signing the authentication statement (where required)	The centre should deal with the irregularity under its own internal procedures. There is no requirement to report the irregularity to WJEC Eduqas (the only exception to this is where WJEC's confidential assessment material has been breached. The breach **must** be reported to WJEC Eduqas). Details of any work which is not the candidate's own must be recorded on the record form.
Actual or suspected candidate malpractice identified by the centre **subsequent** to the candidate signing the authentication statement (where required)	The head of centre must notify WJEC Eduqas at the earliest opportunity using Form JCQ/M1. If malpractice is found WJEC Eduqas will apply a penalty.
Actual or suspected candidate malpractice identified by a moderator **subsequent** to the candidate signing the authentication statement (where required)	WJEC Eduqas will ask the head of centre to conduct a full investigation and report his/her findings.

If a breach of the regulations on the part of the candidate is discovered **after** a candidate has signed the authentication statement, WJEC Eduqas will apply **one** of the following penalties:

- the piece of work will be awarded zero marks
- the candidate will be disqualified from that unit/component for that series
- the candidate will be disqualified from the whole subject for that series
- the candidate will be disqualified from all subjects and barred from re-entering for a period of time.

Equality and fair access

The specification may be followed by any learner, irrespective of gender, ethnic, religious or cultural background. It has been designed to avoid, where possible, features that could, without justification, make it more difficult for a learner to access and achieve because they have a particular protected characteristic.

The protected characteristics under the Equality Act 2010 are age, disability, gender reassignment, pregnancy and maternity, race, religion or belief, sex and sexual orientation.

Access Arrangements and special consideration

Access arrangements and reasonable adjustments are made for eligible learners to enable them to access the assessments and demonstrate their knowledge and skills without changing the demands of the assessment.

Information on access arrangements and reasonable adjustments can be found in the 'JCQ Access Arrangements and Reasonable Adjustments Guidance' (**www.jcq.org.uk**)

We follow the principles set out in this document and, as a consequence of provision for reasonable adjustments, very few learners will encounter a complete barrier to any part of the assessment.

Reasonable adjustments should allow candidates access to an assessment and demonstrate their knowledge and skills without changing the demands of the assessment. An adjustment will not be deemed as reasonable if it affects the validity or reliability of assessment objectives, including competence standards.

Centres must recruit their learners with integrity: this includes assessing each potential learner to establish whether they are able to complete assessments and achieve the qualification, including identifying and implementing reasonable adjustments to allow access to the qualification and its assessments. Where the centre determines that a prospective learner is unable to meet assessment objectives/competence standards despite reasonable adjustments being considered, this should be communicated in writing to the learner and a collaborative decision reached on whether they proceed with the qualification.

Special Consideration is a post examination adjustment to a candidate's mark or grade to reflect temporary injury, illness or other indisposition at the time of the examination/assessment. WJEC Eduqas adhere to the conditions and procedures set out in the *JCQ A Guide to the Special Consideration Process*: all special consideration requests are subject to the eligibility criteria set out in this document. There are two types of special consideration: *Present but Disadvantaged* and *Absent*.

Where a candidate has completed an assessment but has been disadvantaged, WJEC Eduqas will consider applying a small percentage tariff to the candidate's marks, to compensate for the disadvantage. The tariff awarded (1-5%) is determined by WJEC Eduqas and is based on the nature of the disadvantage and the impact on the candidate.

Where a candidate has been absent from an assessment (for an acceptable reason), WJEC Eduqas will consider calculating an estimated assessment UMS via the special consideration absence process, based on the candidate's performance in other (completed) assessments within the qualification.

Candidates may not be eligible for a Special Consideration *Absent* if completion of an assessment is mandatory to be awarded the qualification.

Further information on Special Consideration Absent for controlled assessments/NEAs, including eligibility criteria, is available in the JCQ Instruction for Conducting Non-Examination Assessments (Chapter 8).

Internal Appeals

Centres must have a written internal appeals procedure relating to internal assessment decisions in all qualifications. This is stated in the JCQ document General Regulations for Approved Centres. Details of this procedure must be communicated, made widely available and accessible to all candidates. Giving candidates access to their marks is an important part of the procedure.

The JCQ document General Regulations for Approved Centres may be downloaded from the JCQ website: https://www.jcq.org.uk/exams-office/general-regulations

Results reporting

The Institute for Apprenticeships and Technical Education will certificate Learners who have successfully completed all elements of the T Level Technical Qualification Building Services Engineering for Construction.

T Level results will be released on the Level 3 results day in August.

Post-Results Services and Appeals

Centres may appeals decisions made by WJEC Eduqas in respect of Results, Malpractice, Special Consideration, Access Arrangements and Reasonable Adjustments.

For further details of post results services and appeals, please visit the WJEC Eduqas website at: **www.eduqas.co.uk/**

Terms of Business and General Conditions

T Level Providers must adhere to our Terms of Business and General Conditions for WJEC Centres, as published on our **website**.

8. Components

Content of components

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

- Eduqas reference number.
- Title
- Level
- Guided learning hours (provisional)
- Introduction section
- What learners need to learn.
- Links to Maths, English and digital skills.
- Assessment method.
- Content
- Range and amplification.
- Scheme of Assessment*.

*Occupational specialisms only.

Building Services Engineering Core
(Eduqas reference number TBC)

Level	3
GLH	520
What is this component about?	This component focuses on the learner's knowledge and understanding of contexts, concepts, theories and principles relevant to Building Services Engineering (BSE). The component is designed to raise learners' awareness of the industries and develop knowledge and understanding of: • Fundamental Health and 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 • Maintenance principles
Underpinning knowledge outcome	On completion of the BSE Core, learners will understand 1. Health and safety in construction 2. Construction science principles 3. Construction design principles 4. Construction and the built environment industry 5. Construction sustainability principles 6. Construction measurement principles 7. Building technology principles 8. Construction 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. Tools, equipment and materials
Learner preparation	Learners may prepare by asking themselves questions such as: • How are teams of different specialists co-ordinated to work together on construction projects? • What the different career pathways and destinations are within the construction industry? • What factors influence whether construction projects are profitable? • What kind of tasks does a building service engineer perform? • What systems do building service engineers work on? • What tools and equipment do building service engineers use as part of their role?

Maths, English and Digital skills	Completion of this component will give learners the opportunity to develop their Maths, English and digital skills. Where applicable, this information is included under the knowledge outcome.
Assessment method	Two Knowledge tests Employer-set project

1. Health and safety in construction	
Content	**Range and amplification**
1.1 Construction legislation and regulations	The role and purpose of legislation and regulations in the construction industry, including individual responsibilities: Legislation: • Health and Safety at Work Act (HASAWA) • Reporting Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) • Control of Substances Hazardous to Health (COSHH). Regulations: • Control of Asbestos Regulations • 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 Regulations • waste management • Electricity at Work Regulations • Control of Vibrations at Work Regulations • Confined Spaces Regulations • Management of the Health and Safety Act Regulations • lone working • Environmental Health and Safety Regulations. Responsibilities of members of the construction team: • Employers (including employer representatives) • Designers • Main contractors • Sub-contractors • Employees • Self-employed (labour only) • Clients (customers). The legal status of health and safety guidance materials: • Acts of Parliament • Regulations • Approved Codes of Practice • HSE guidance notes.

	Regulations relating to provisions of welfare facilities during construction work to include: • toilets • washing facilities • drinking water • heating • changing rooms and lockers • rest facilities etc. • how to access information related to welfare responsibilities onsite. The powers of the health and safety inspectorate and local authorities and their role in imposing: • improvement notice • prohibition notice • powers of prosecution. and the implications of these to: • employers • employees • general public. The implications of not adhering to health and safety legislation to the client and business: • Improvement notice detailing what's wrong, any changes you need to make to put things right, how long you have to make those changes. • Prohibition notice if there is a risk of serious personal injury now or in the future. A prohibition notice orders you to stop doing something until you have made it safe to continue. • Prosecution for breaking health and safety laws or for failing to comply with an improvement notice or a prohibition notice. The courts can impose a fine or in some cases recommend a prison sentence. The implications of not adhering to health and safety legislation when incidences of injury, accidents and or death happen in the workplace.
	Skills CSB, EC5

1.2 Public liability insurance and employers liability insurance	What liability insurance is and what the current requirements are relating to public and employer liability insurance for construction employees and employers. Areas covered by public liability, for example: • injury • illness/death • legal action • compensation. Areas covered by employers liability, for example: • employee and public injury • accidents • compensation • medical costs • legal costs • loss of income.
	Skills EC5
1.3 Approved Codes of Practice (ACoPs)	Where to obtain approved codes of practice through the HSE L (legal) series publications, to include: • L5: Control of substances hazardous to health (Sixth edition) • L8: Legionnaires' disease. The control of legionella bacteria in water systems. Approved Code of Practice and guidance • L22: Safe use of work equipment. Provision and Use of Work Equipment Regulations 1998. Approved Code of Practice and guidance • L23: Manual handling. Manual Handling Operations Regulations 1992 – Guidance on Regulations (fourth edition) • L24: Workplace health, safety and welfare. Workplace (Health, Safety and Welfare) Regulations 1992. Approved Code of Practice • L25: Personal protective equipment at work (Second edition) • L74: First aid at work. The Health and safety (First Aid) Regulations 1981 • L113: Safe use of lifting equipment. Lifting Operations and Lifting Equipment Regulations 1998 • L140: Hand-arm vibration • L143: Work with materials containing asbestos. Control of Asbestos Regulations 2012. The use, purpose and legal status of approved codes of practice and how these are applied in the construction industry. Where to obtain the Institute of Engineering and Technology (IET) Codes and Guidance. The use, purpose and legal status of the Institute of Engineering and Technology (IET) Codes and Guidance and how these are applied in the construction industry.
	Skills EC5

<table>
<tr><td>1.4 Development of safe systems of work</td><td>How safe systems of work are developed and used in construction projects.

Safe systems of work include:
company management systems
risk assessments and method statements (RAMs)
permits to work
safety notices
Construction Skills Certifications Scheme (CSCS) cards.
Roles and responsibilities, recording and reviewing and any potential implications of not having systems in place including:
how to write method statements
how to complete risk assessments
how to complete a COSHH assessment
how to apply Construction Design and Management (CDM)
how to estimate risk based on likelihood and severity.
The categories of safety signs including:
Mandatory
Prohibition
Information
Warning.</td></tr>
<tr><td></td><td>Skills EC3, EC5, MC2</td></tr>
<tr><td>1.5 Safety conscious procedures</td><td>The importance of safety-conscious procedures; procedures that aim to promote and support safety consciousness within construction sites/environments/workshop areas including:
reporting of potential hazards following the company's reporting procedure and RIDDOR.
procedures that must be followed when hazards cannot be eliminated completely.
construction site inductions for all new visitors and workers including identification of risks and hazards and the control measures used to mitigate them.
on and off the job health and safety training and related qualifications.
toolbox talks which involve short training sessions at a place of work to discuss health and safety issues and inform personnel about new hazards that may have recently arisen.
good housekeeping including systematic ways of working and keeping areas clean and clear.
The benefits of having safety conscious procedures in place and the potential consequences of not adhering to them, for example:
injury/death
loss of business
fines
increased costs
project timescales slipping.</td></tr>
</table>

	Construction Skills Certification Scheme (CSCS), Site Management Safety Training Scheme (SMSTS), and Site Supervisors Safety Training Scheme (SSSTS): • Types of card • Card requirements.
	Skills EC3, EC5, MC2
1.6 Safety inspection of a work environment	Review of area/site/workshop by employee and employer, the use of guidance and documentation to record visual inspections completed in the construction industry. The safety inspection methods used to ensure the workplace is safe, including: • Health & Safety Audit • Equipment checks • Safety surveys • Incident inspections. Types and use of recording documentation used for inspections, including: • documents that can be used to record the results of inspectors, such as HSE forms • access equipment safety checklists: step ladders, ladders, roof ladders and crawling boards, mobile tower scaffolds, fixed scaffolds, mobile elevated work platforms including scissor lifts and cherry pickers • work equipment safety checklists, asset register, checklists • area/location checklists.
	Skills CSA, CSC, EC3
1.7 Safe working practices for the safe isolation of systems	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. Equipment required for safe isolation including: • warning notices • lock off devices • voltage indicators • proving units. Isolation of incoming supplies for: • gas • water • electricity. The methods used to safely isolate gas, water and electricity services/systems The use of permits-to-work for the isolation of systems and supplies.
	Skills CSC

1.8 Implications of poor health and safety on building performance and individual stakeholders	The consequences of not working safely on site to individual stakeholders, and the impact on building projects and timelines being affected by poor health and safety. The implications of poor health and safety and whom these impacts at different levels i.e. employee, employer/business, client/customer/public, include: • Accidents: incident that happens unexpectedly and unintentionally, typically resulting in damage or injury. • Injuries: harm or damage to someone's body caused by an accident. • Fatalities: death by accident. • Slips, trips, falls resulting in accidents, injuries or fatalities. • Down time: a pause in work due to a health and safety issue. • Financial: a loss of income or work due to a health and safety issue or financial penalties. • Reputation: poor business reputation as the result of poor health and safety practices, this often leads to financial implications. • Environmental: an event that results in environmental or equipment damage. • Near misses: an event that has the potential to cause but does not actually result in human injury.
1.9 Recording and reporting of safety incidents and near misses	The correct process to follow when reporting an incident or near miss in the workplace to include: • accident book • reporting procedure • accident and incident reporting policy • RIDDOR reportable incidents. The purpose and recording of safety incidents and near miss online forms and the information contained within these online forms.
	Skills CSA CSD EC3

1.10 Emergency procedures for unsafe situations	Unsafe situations include: • fire • gas leaks • terrorist threats • water leak • carbon monoxide • chemical spillage • potential electric shock. The correct procedures to follow if unsafe situations occur in the workplace including: • how to raise the alarm • contact emergency services • designated evacuation routes • assembly points • register and roll call • use of spill kits and gas and carbon monoxide devices • actions to be taken when dealing with fire situations if safe to do so. Emergency procedures include: • Gas Industry Unsafe Situations Procedure (GIUSP) • Gas Safety Installation and Use Regulations (GSIUR) • evacuations • electric shock • first aid. Identification and use of different types of fire extinguishers and uses against classes of fire: • Red – water – class A • Cream – foam – class A, class B • Blue – dry powder – class A, class B, class C, class D, electrical • Black – CO2 – class B, electrical • Yellow – wet chemical – class A, class F
	Skills CSC EC5

1.11 Types of (Personal Protective Equipment) PPE	The purpose, selection and correct use of appropriate PPE and RPE (Respiratory Protective Equipment) to mitigate risks including the body parts they are intended to protect. Types of PPE include: • 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) • foot protection (safety shoes, safety boots, safety trainers) • vibration protection • harnesses • high visibility jacket. Types of RPE include: • face fitting • dust masks • full face visor • respirators.
1.12 First aid facilities	The first aid provision that must be available in the work area in accordance with Health and Safety (first aid) regulations. The requirement for employers to: • carry out a workplace-specific first-aid assessment • provide first-aid kits for their workers • appoint a person to take charge of their first-aid arrangements and to call the emergency services when necessary • appoint a trained first-aider • provide staff training, information and instruction.
1.13 Safety Signs	The symbols for hazardous substances. The meaning of each pictogram in the Classification, Labelling and Packaging CLP Regulation and where they would be encountered, to include: • Explosive • Flammable • Oxidising • Gas under pressure • Corrosive • Acute toxicity • Health hazard • Hazardous to the environment.

1.14 Safe practices and procedures for the use of access equipment and manual handling	The different types of access equipment, including: • ladders • roof ladders and crawling boards • mobile and fixed scaffold towers • platforms • trestles • step • podiums • staging • mobile elevated work platform (MEWP cherry picker and scissor lifts). The safety checks to be carried out on access equipment, including: • visual • tagging • fit for purpose • secure level ground • operative's competency for use of equipment. Safe erection methods for access equipment, calculating suitable ratios and heights. Factors that influence the choice of equipment for carrying out work at height, based on the work being carried out, duration at work, action points for heights. The procedure for manual handling operations: • assessment of a safe load • calculation of a mass and weight for loads • safe kinetic lifting technique • use of lifting aids, e.g. wheelbarrows, sack barrow and pallet trucks.
	Skills MC4

1.15 Safe practices and procedures for working in excavations and confined spaces	Dangers associated with excavations, including: • flooding • obstruction of an escape route • explosion • collapse • buried services. Safety measures required when working in excavations, including: • signs • safety barriers • vehicle stops • permit to work • safe means of entry and egress. Dangers associated with confined spaces, including: • inadequate ventilation • inadequate lighting • flooding • obstruction of an escape route • explosion. Requirements for safe working in confined spaces including: • safe means of escape • adequate ventilation/air supply • RPE.
	Skills EC5

<table>
<tr><th colspan="2">2. Construction science principles</th></tr>
<tr><th>Content</th><th>Range and amplification</th></tr>
<tr><td rowspan="2">2.1 International System of Units (SI)</td><td>The Internationally recognised (SI) units of measurement and their application and use in building services engineering formulae and calculations including multiples and sub-multiples.

Units:
• kilogram (mass) kg
• second (time) s
• metre (length) m
• ampere (current) A
• kelvin (temperature) k
• candela (cd) (unit of luminous intensity).

Sub-multiples:
• milligram
• gram tonne (mass)
• hour, day, milli-second (time)
• millimetre, centimetre
• kilometre (length)
• milliampere (current).</td></tr>
<tr><td>Skills MC1</td></tr>
<tr><td>2.2 Derived SI units</td><td>All derived SI units and their application and use in building services engineering formulae and calculations.

Use of SI units and derived multiples in calculations.

Derived SI units:
• newton (force) N
• pascal (pressure) Pa
• joule (energy/work) J
• watt (Power) W
• volt (electromotive force/potential difference) V
• ohm (resistance) Ω
• frequency (Hertz) Hz
• weber (magnetic flux) Wb
• degrees-Celsius (temperature) °C
• lumens (luminous flux) lm
• lux (illuminance) lux
• decibel (sound) db
• bar (pressure)
• 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)
• resistivity (ohm-metre).</td></tr>
</table>

	Multiples: • micro (μ) x 10-6 • milli (m) x 10-3, kilo (k) x 103 • mega (M) x 106 • giga (G) x 109
	Skills MC3 MC4
2.3 Materials science principles	The principles of materials science in construction BSE design and how systems will perform in terms of durability and stability. Materials science principles include: • material properties • chemical composition • degradation • failure • effects of environmental conditions • ductility • elasticity • malleability • conductivity • tensile strength • compressive • strength • durability • expansion • contraction • resistance (electrical) • advantages and disadvantages. Properties of materials, their uses and the reasons that they are suitable for applications, or limitations where not suitable. Common BSE materials include: • pure metals • ferrous materials • non-ferrous materials • alloys/solders • enamels • galvanising • plastics (PVC thermosetting and thermoplastic) • fireclays/ceramics • natural and synthetic rubbers • natural wood/timber • engineered wood. Uses of materials include: • pipes • ducts • conduits • trunking • cables • ladders

	• racks • trays • sub-structure • super-structure • building fabric. Calculating the thermal expansion of materials: change in length = coefficient of thermal expansion x change in temperature x original length Environmental conditions 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 • heat effects • expansion • contraction • changes in resistance.
	Skills CSB MC4
2.4 Mechanical science principles	Key principles of mechanical science and how they are used to inform construction methods, to include: • force • energy • power • levers • pulleys • gears • acceleration • work • work done • efficiency. Basic mechanics, including: • theory of moment • action and reaction • centre of gravity • equilibrium • velocity and ratio • mechanical advantage • class I II and III levers • pulleys • displacement • Archimedes screw.

	Effects of gravity in terms of acceleration, relationship between energy and power in terms of time and how efficiency changes input and output power values including typical losses associated with efficiency. The relationship between acceleration (a), force, work (w), energy (e), power (p), work done (w) and efficiency. Calculations for all mechanical science principles and basic mechanics in range including formulae and relationships between: • $Force = m \times a$ • $E = F \times d$ • $P = \frac{F \times d}{t}$ • $W = F \times d$
2.5 Electricity principles	Sources of power and means of generating electricity including: • fossil fuels • biofuels • nuclear energy • hydro, pumped (stored) hydro • photo-voltaic (PV) • wind turbines. Basic principles of how these sources of energy are converted into electricity including the use of: • heat • turbines • gears • chemical processes • pumps. Transmission and distribution of electricity in the UK from generators to consumer including: • transmission network arrangements • pylons • overhead systems • underground systems • typical voltages (400 kV, 275 kV). Distribution network arrangements: • pylon • overhead systems • underground systems • typical voltages (33 kV, 11 kV, 400/230 V). Advantages and disadvantages of stepping up and stepping down voltages and current in transmission and distribution systems including: • sizes of conductor • thickness of insulation materials

	• demand. Types, purpose, advantages and limitations of transformers used in transmission and distribution systems including: • air cooled • oil cooled • step up • step down • ratios • three-phase • single-phase • star • delta • sub-stations. Arrangements for distributing electricity into buildings such as: • industrial • commercial and domestic including overhead wiring • underground wiring • single-phase • three-phase • prosumer arrangements. Why arrangements are used for different building types and demands. Series/parallel circuits and the effects of voltage, current, resistance and power in basic DC circuits. Calculating values in DC series and parallel circuits including: • Ohm's law • power dissipation (I2 R = W) • current (A) • voltage (V) • resistance (Ω) • power (W) Measuring and calculating values of current and voltage across components in series and parallel DC circuits. • $V = I \times R$ • $P = V \times I$ • $P = I^2 R$ • $R_{total} = R_1 + R_2 \ldots$ • $R_{total} = \frac{1}{R_1 + R_2 \ldots}$ Alternating current principles including simple sine-wave properties such as: • frequency • peak voltages • rms voltages

	• single-phase voltage • three-phase voltage. Typical voltages used in BSE systems including why different equipment has different voltage supplies such as: • 12V • 24V • 110V • 230V • 400V. Circuit **protective devices** used on BSE electrical circuits including basic operating principles and why each are selected. Electricity principles in relation to BSE systems in the completed building. **Protective devices include:** • Circuit Breakers (CB) • Residual Current Devices (RCD) • Residual Current Breakers with Overload (RCBO) • Cartridge fuses.
	Skills MC2 MC4
2.6 Structural science principles	The use and effects of structural science principles. How structural science principles inform the construction, design and use of buildings. Structural science principles: • forces • loads • common BSE materials • structural members. Structural members: • footings • foundations • walls • beams • trusses • roofs • columns • beams • girder • joists • lintels. Types of loads acting on structures: • vertical • horizontal • longitudinal • lateral.

	How forces act on building structures and structural members including common causes of the forces such as: • load • fixings • weight/mass of equipment • weather • supporting for other building members • use and supporting building services equipment. and the different forces they produce: • compression • torsion stress • tension • bending • shear. How the different materials act under the different forces and loads and suitability of different materials for use as structural members. Notches, holes and chases and how they impact on the strength of structural members. Calculations to determine the correct drilling and notching zones in structural members as given in IET Guide to the Building Regulations or IET On-Site Guide leading to conforming with Approved Document A. Permitted chase zones in structural members leading to conforming with Building Regulations: Approved Document A including calculations to determine the correct depth and width. Where cables and pipes can be concealed in walls including measures needed to protect them from accidental impact by nails and screws.
	Skills CSB MC4 DC4
2.7 Heat principles	Key principles of heat transfer and its cause and effect within the built environment. Heat principles: • heat transfer • air temperature • air density humidity • condensation air movement • heat loss • thermal conductivity • resistance • convection cycles.

	Types of heat transfer and how they are used to heat areas or lessen the environmental impact: • convection • conduction • radiation. The different characteristics of air and how these characteristics impact on a building and building materials: • temperature • density • humidity • specific heat capacity • thermal conductivity • condensation • moisture. Causes of mould, mildew and rot, and how these can be avoided. How air comfort and the quality of air is created and maintained by the design of a building or building services. Calculating the energy required to heat air using its specific heat capacity. $SHC = m \times c \times (T_2 - T_1)$ Causes of heat loss in buildings. Calculating the heat loss in buildings based on the thermal conductivity of common materials used to construct the building fabric, changes of air and ventilation. Calculating heat loss using: • R = $^{T}/_{K}$, and • Heat Loss – Q=UA (T1-T2) • U values for walls, windows, doors, floors, air changes. Common materials include: • blockwork • brick • chipboard • concrete • glass • plasterboard • timber. Selecting suitable methods of heating and cooling a building by different sources of heat and building design. Sources of heat include: • radiators • electric panel heater • electric storage heaters

	• electric radiation heaters • underfloor heating (wet and electric) solar thermal • heat recovery units • ground and air source heat pumps.
	Skills MC3 MC4
2.8 Light principles	How artificial and natural light are incorporated into the design of a building considering energy use and pleasant environment for the end user. Light principles include: • refraction • difference in artificial and natural light • glare • directed and reflected light • flow of light energy • daylight factor • colour rendering • efficacy (lumens/watt) diffusers • louvres, movement sensors • daylight sensors. The effects of glare in a working environment. Methods used to diffuse light and reduce glare. Methods of switching artificial lighting to reduce energy consumption. Calculate efficacy of lamps and luminaires. $efficacy = \frac{lumens}{Watts}$
	Skills MC3 MC4

<table>
<tr><td rowspan="2">2.9 Acoustics principles</td><td>Key principles of acoustics and acoustic barriers and how they are applied to the built environment to control and limit unwanted transference of sound internally and externally:

Acoustic barriers include:
acoustic hoods
insulation sheeting in or on wall
insulation between floors
sound transmission class (STC)
acoustic materials
sound absorption.
Factors that affect acoustics of types of buildings including:
frequencies
reverberation
reverberation time
decibels
focusing
resonance
echo.
Acoustic principles in action in the construction industry.

The effect on the operative and upon the wider environment through noise pollution, and external sources of sound and noise including those from BSE systems.

Use of decibels (Db): as a unit of measure, additional levels and threshold limits.

Compliance with approved document E (resistance to sound).</td></tr>
<tr><td>Skills MC4</td></tr>
<tr><td rowspan="2">2.10 Earth science principles</td><td>Earth science principles and how these impact the built environment and basic design principles for BSE systems.

Earth science principles include:
physical geography, such as water levels and water courses and their use for surface water drainage, including the impact of not controlling the collection of surface storm water
hydrology, including lakes, rivers and water cycles
geology, including structure, conditions and ground water and how these impact on renewable technologies
weather, including climate change, temperature, rainfall and wind
earth forces, such as gravitational force and electromagnetic force
natural phenomena, such as earthquakes and subsidence.</td></tr>
<tr><td>Skills MS5</td></tr>
</table>

<table>
<tr><th colspan="2">3. Construction design principles</th></tr>
<tr><th>Content</th><th>Range and amplification</th></tr>
<tr><td>3.1 Benefits of good design</td><td>
The benefits of good design include:

efficiency
aesthetics
sustainability
wellbeing
improved quality of life
value for money
local/community improvement
on budget.

The potential implications of poor design include:

reduced saleability
reduced efficiencies
damage to reputation
poor safety standards including fire and health risks
mould infestation
negative effect on local community and the different parties affected in the construction chain:

client
project sponsor
project team
consultants
suppliers
contractors and sub-contractors
end users
efficient use of materials
quantity control.

Factors that can impact on the profitability of projects, including:

over specification leading to higher costs
difficulty of assembly leading to increased timescales and increased budgets
Corporate Social Responsibilities (CSR)
vernacular construction
codes for sustainable homes
project scales
brownfield versus greenfield sites.

The importance of coordination between the various disciplines to ensure that there is no negative impact on timescales for completion of projects, the cost of projects and the aesthetics of a building.

Methods of communicating or displaying the benefits of good design using mathematical graphs, charts or diagrams based on data.

Optimising work processes using data gathering and evaluation.
</td></tr>
<tr><td></td><td>Skills CSC EC6 MC2 MC7 MC8 MC10</td></tr>
</table>

3.2 Design principles	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. Design principles include: • environmental protection • safety • economics • aesthetics • buildability manufacture • installation and construction feasibility • integration of services • infrastructure • inclusivity • accessibility • heat • acoustics • lighting • air quality. The stages and outcomes of the Royal Institute of British Architecture (RIBA) plan of work. Environmental protection, including: • sustainable technologies and materials • energy sources • energy reduction materials • local and natural environment • grey water harvesting. Safe construction methods and how a building is going to be constructed, serviced and maintained in the future to protect the health and safety of construction and maintenance operatives. Aesthetics, including: • design features • materials used • colour. Buildability manufacture, including: • installation • feasibility • modern methods of construction • inclusivity • construction timescales. Provisions and services, including: • gas • electric • water • wastewater (surface and foul/sewage) • telecommunications.

	Comparison of methods of construction, including: • timber frame/traditional oak frame • modern timber frame erection • ICF (insulated concrete formwork) • cob • limecrete and straw bale • thin joint system and off-site construction prefabricated • modular design. Listed buildings regulations: • Heritage regulations and restrictions (listed buildings grade I II* II) • conservation area • national parks • Areas of Outstanding Natural Beauty (AONB). Local authority restrictions: • life cycle costs • life cycle CO2 emissions.
	Skills CS3 EC6 DC1 DC6

3.3 Design process from conception to completion	Key stages of the design process from initial enquiry to completed design:
	• research
	• site analysis
	• assessment of current and proposed characteristics
	• planning
	• approval/review
	• design sign off.
	
	Factors that may impact or influence design changes:
	• Construction Design and Management (CDM)
	• budget
	• end user requirements including:
	    • site analysis:
	        • location
	        • size
	        • topography
	    • planning:
	        • local planning requirements (consent/approval)
	        • listed buildings and listed buildings consent
	        • environmental factors and regulations
	        • how to make a planning application
	        • how the approval is gained
	        • being sympathetic to the local environment
	        • planning objections and pressure groups
	        • appeals procedures
	• feasibility study and how to use data and time considerations to calculate a component cost within a project and determine or justify outcomes

	• animals/infestation/ Site of Specials Scientific Interest (SSSI)/protection • planning for utilities and connecting to services (water, drainage, gas, electric) • planning for building services • how frontage line and building lines are determined • planning key stages and the displaying of milestones, timelines or phases using tables, graphs and bar charts • project planning, Gantt charts, Critical path, use of information for costing and efficient resources. Planning factors including: • planning consent/approval • local plan requirements • being sympathetic to the local environment • planning objections and pressure groups • listed building consent.
	CSA EC3 EC5 EC6 MC7 MC9
3.4 The concept of the 'whole building', including life cycle assessment	The concept of the whole building and how design and construction is influenced by construction systems working together, including life cycle assessments and how they influence project planning and are influenced by regulations and legislation. How environmental regulations/legislations and costs, inform on planning greener and smarter building with less impact overall on the environment. Including material acquisition, manufacturing, use and final disposal. Environmental regulations/legislations include: • Environmental Protection Act • Climate Change Act • Clean Air Act • Water Act • Building Regulations • Control of Pollution (Oil Storage) (England) Regulations • COSHH • WEEE • Hazardous Waste regulations • best practice for pollution prevention. Stages of life cycle assessment in construction: • raw material or recycled material supply • manufacture of construction products • the construction process stage • occupation, use and maintenance stage • demolition • material disposal or recycling.

4. Construction and the built environment industry	
Content	**Range and amplification**

4.1 Structure of the construction industry	The structure of the construction industry, including:
	• roles and business types
	  ◦ sole traders
	  ◦ contractors
	  ◦ sub-contractors
	  ◦ definitions of small, medium and large organisations
	• roles and client types
	  ◦ private
	  ◦ commercial
	  ◦ public limited companies
	  ◦ the Government
	• size and scale in determining who is involved.
	
	The role of building regulation and the relationship with the customer/client:
	• ensuring safety
	• health and welfare in and around built environments.
	
	The range of work undertaken and the factors that define these work environments:
	• commercial
	• residential
	• industrial
	• health
	• retail
	• recreational
	• leisure
	• utilities
	• transport
	• new build
	• retrofit.

4.2 How the construction industry serves the economy as a whole	How the construction industry contributes to the UK economy both nationally and locally with reference to:
	• wealth generation from construction developments
	• area regeneration
	• improvements in infrastructure
	• community developments, including:
	  ◦ housing transport
	  ◦ leisure facilities
	  ◦ educational establishments
	  ◦ hospitals.
	
	Factors that impact growth of the industry, including:
	• political changes
	• developments in technology/practice
	• skilled labour resources
	• environmental considerations.

	Climate Change Act – the consequence for the country of missing the carbon budgets, the net zero target, and the related impact on construction (retrofits/insulation), heating systems (no more gas boilers) and electric vehicle charging points.
	
	Impact of infrastructure projects on:
	• transport networks
	• provision of services:
	    • gas
	    • electricity
	    • water
	    • communications technology
	• water management:
	    • drainage
	    • sewer systems
	    • flood defences
	• renewable energy projects.

4.3 Integration of the supply chain through partnering and collaborative practices	The integration of all partners of the supply chain in the building process. • client • architect • engineers • building contractor • sub-contractors • operatives • manufacturers • suppliers. An awareness of the importance of effective planning (inventory management) and collaborative working (integrated systems and agreed roles and responsibilities and change management approaches) in ensuring that the project is completed to standards, budget and on time, and the consequences of poor planning and communication (disruption, increased costs, reputation).
	Skills CSD
4.4 Procurement of projects within the construction sector	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: • need/demand • tendering and bidding processes • supply chain • estimation • quotation • tender documentation. The types of common procurement routes: • contractor led • design and build • fast track

	• lump sum • single stage • two stage. The methods of tendering: • open • negotiated • selective • two-stage • preferred supplier. Project, cash flow management, contract payment periods for suppliers, contractors and sub-contractors. Documentation and basic information required for procurement and tendering: • expression of interest • a letter of invitation to tender • pre-construction information • a tender pricing document • design drawings • specifications • bills of quantities • schedules – schedules of work • activity schedules. Methods of estimation or evaluation per unit or overall costings using: • data • tables • costs per item • bulk costs • discounts • hidden or overhead costs. Methods for estimating, calculating and error checking costings where costings are very large or very small numbers represented in different numerical values, for example: • pence [p] • thousands [k] • millions [M] • billions [B].
	Skills MC2 MC9 MC10
4.5 Managing change requests from various parties	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. The use of: • variation orders • daywork sheets • contracts.
	Skills CSC DC3

<table>
<tr>
<td>4.6 Roles and responsibilities of the construction professions and operatives</td>
<td>The key job roles (position or part played) and responsibilities (types of tasks and duties they are expected to complete) and reporting lines/lines of escalation of construction professionals and operatives, and the stages they may be involved in a construction.

Construction professions include:
• architect
• clerk of works
• quantity surveyor
• civil engineer
• ground works
• plant occupation
• non-skilled operative
• building services design engineer
• building services engineer technician
• mechanical building services engineer
• electrical building services engineer
• mechanical design engineer (Building Services)
• building services engineer site management
• facilities manager
• client representatives
• contract managers
• planners and building inspectors
• manufacturers
• mechanical engineer CAD technician
• BIM designer
• retrofit coordinators
• retrofit assessors
• contractors
• all operativesf

BSE operatives:
• plumber
• electrician
• heating and ventilation fitter
• gas engineer
• air conditioning engineer
• site supervisor
• trade supervisor.

Onsite construction operatives:
• joiner
• plasterer
• painter and decorator
• bricklayer
• tiler
• trade supervisor
• site supervisor.

An appreciation of potential career progression routes aligned to the disciplines.</td>
</tr>
</table>

4.7 Trade Associations and Professional Engineering Bodies in relation the BSE sector	The trade associations, professional engineering and their responsibilities in relation to the BSE sector. Trade Associations include: • Air Conditioning and Refrigeration Industry Board (ACRIB) • Association of Plumbing & Heating Contractors (APHC) • Build Engineering Services Association (BESA) • Electrical Contractors Association (ECA) • Federation of Environmental Trade Associations (FETA) • Renewable Energy Association (REA). Professional Engineering Institutions include: • Chartered Institution of Building Services Engineers (CIBSE) • Chartered Institute of Plumbing and Heating Engineering (CIPHE) • Institute of Engineering and Technology (IET) • Institute of Lighting Professionals (ILP) • Institute of Refrigeration (IoR). The advice and guidance on technical safety and legislative aspects.
4.8 The role of Continuing Professional Development (CPD) in developing the knowledge and skills of those working in the sector	The role of CPD to individuals, companies and the building industry as a whole. The importance of CPD in maintaining occupational competence and best practice, and the link to keeping clients/customers/public safe, to include: • upskilling staff • legal requirements • product knowledge. CPD and career progression. Types of development include: • apprenticeships • degree apprenticeships • graduate training programmes • higher technical qualifications. Types of CPD include: • formal • in house • qualifications • work experience • self-learning • chartered etc. Providers of CPD include: • Professional bodies • Accreditation bodies • Certification bodies • manufacturers • in house/toolbox talk.

<table>
<tr>
<td rowspan="2">4.9 Building information modelling (BIM)</td>
<td>The aspects of BIM and the effect it has on real time project delivery in a collaborative way.

BIM government levels 1-3:

Level 1 typically comprises a mixture of 3D CAD for concept work, and 2D for drafting of statutory approval documentation and Production Information
Level 2 is distinguished by collaborative working, and requires an information exchange process which is specific to that project and coordinated between various systems and project participants
Level 3 projects at this level are fully collaborative. They use a single, shared project view for data integration, which all parties can access and modify as allowed through process and security controls.

The characteristics and protocols associated with BIM and the implementation of BIM within the Royal Institute of British Architects (RIBA) Digital Plan of Work (DPoW):

enables digital technology design and communication
embeds key product and asset data in all project stages
manages information throughout the project life cycle, using three-dimensional (3D) computer modelling
provides an information repository for digital data project information throughout a design and construction project, with the capability to manipulate and produce information and support information sharing
produces unified information output for the client at handover
provides a model of the building through the life cycle that can be updated – the model is used as part of the decommissioning and recycling of the building at the end of its life.

The collaborative role of BIM in delivering real time projects:

The stages of the RIBA Digital Plan of Work (DPoW) and its application to construction projects:

Preparation and brief
Concept design
Developed design
Technical design
Build and commission
Handover and close out
Operation
End of life.

</td>
</tr>
<tr>
<td>Skills CSD</td>
</tr>
</table>

4.10 PESTLE factors	The application of current examples of PESTLE factors to situations that may impact on the construction industry. PESTLE analysis: • Political factors determining government influence on the economy or a certain industry • Economic factors outlining economy's performance • Social: scrutiny of the social environment • Technological: innovations in technology that may affect the operations of the industry • Legal implications of legislation to a project, including contract law, building regulations, building control, HASWA, civil law • Environmental: factors that influence the surrounding environment.
	Skills CSD
4.11 Documentation used in construction projects	The purpose and typical contents of documents used through the construction process: • Take off sheets: Used to calculate quantities of building materials and labour costs for a construction project • Contracts: Lump-sum and measurement contracts • Schedule of rates: suppliers agreeing a schedule of rates for a set period of time • Estimates: A prediction of costs for building work provided by contractors for clients • Quotations: A fixed price for goods and services offered by contractors or subcontractors to potential clients • Delivery notes: document that accompanies a shipment from a supplier and describes the goods and quantities being delivered • Purchase orders: a request for goods and services • Bill of quantities: a document usually produced for the client by a quantity surveyor at the planning stage of a building project • Wiring diagrams: Wiring diagrams are technical drawings provided by the client to building services engineers, such as electricians, for the installation of electrical systems and circuits. Estimating based on approximate costings where some detail is lacking. Processing data from various sources or documentation to cost a task or component in the form of a schedule of rates for a project.
	Skills MC2 MC9

4.12 Procedures for handing over projects to clients	The procedure for handing over projects to client: • contents and purpose of operation and maintenance manuals • demonstration of use and client understanding • guarantee periods • snagging. Documentation includes: • the building owner's manual and user guide • guidance documents on defects reporting and aftercare • operational and maintenance manuals • a building regulations completion certificate • the health and safety file (including construction drawings/BIM) • the building log book • testing and commissioning certificates, for example a Building Regulations Compliance Certificate for gas installations • the building warranty/insurance certificate and policy booklet.

5. Construction sustainability principles	
Content	**Range and amplification**
5.1 Sustainability when planning and delivering a construction project	The importance of sustainability and environmental protection in relation to the stages of project development across different types/scales of construction project as well as environmental protection, including: • design • planning • delivery. Sustainability considerations when planning a project including: • using renewable and recyclable resources • reducing energy consumption and waste • creating a healthy and environmentally friendly environment • protecting the natural environment. The relevance of: • local sourcing • resource protection • re-use and refurbishment of materials. The common sustainability assessment methods used in planning and delivering a construction project including: • BREEAM • LEED • TRADA • Well building standards • Carbon footprints. The purpose of PAS 2035 and PAS 2038.
	Skills MC3
5.2 Types of sustainable solutions	The definition of sustainable. Types of sustainable solutions: • social • environmental • economic • human (habitability). The use and benefits of sustainable solutions including: • prefab construction • self-heal concrete • energy efficiency systems • insulation • green roofs • greywater harvesting systems • use of soakaways • sustainable drainage • smart glass/electrochromic glass.

	How sustainable materials are used in construction of building and roofs/locally sourced (reducing carbon footprint), including: • recycled bricks • tiles/slates • timber products. Sustainable and renewable materials include: • wood • straw bale • cob • recycled glass • paper and plastic • reclaimed timber and masonry/concrete • sheep wool. How renewable technologies can provide sustainable solutions.
	Skills CSB
5.3 Environmental legislation	Environmental legislations include: • Environmental Protection Act • Climate Change Act • Clean Air Act • Water Act • Building Regulations • Waste Electrical and Electronic Equipment (WEEE) • Hazardous Waste Regulations • Control of Pollution (Oil Storage) (England) Regulations • best practice for pollution prevention. 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 • Volatile Organic Compounds (VOCs) • PPE • user guide instructions • environmental risk assessments to assess the likelihood of a business causing harm to the environment. Including describing potential hazards and impacts before taking precautions to reduce the risks. Risks include: waste storage and disposal, emissions, hazardous substances, environmental impact of raw materials and packaging. Key requirements of environmental regulations that must be adhered to whilst working in the building engineering services industry.
	Skills EC5

5.4 Environmental performance measures	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). Measures include: • 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. The types of schemes that can be used to certify levels of environmental performance in construction, including: • BREEAM • Passivhaus • leadership in energy and environmental design (LEED).
	Skills EC5
5.5 Principles of heritage and conservation	Heritage and conservation considerations associated with listed and historical buildings (types of grades and restrictions). Maintenance of existing stock and how current regulations (Planning Act and Heritage Protection Bill) affect the selection of materials used for building activities. Restrictions associated with listed and historical buildings: • listed building grading – Grade I, Grade II* and Grade II • permissions for buildings to be demolished, extended or altered • notification of work to a listed building that involves any element of demolition. Legislation and guidance relating to listed buildings and heritage sites: • Planning (Listed Buildings and Conservation Areas) Act • Heritage Protection Bill.
	Skills EC5

5.6 Lean construction	The principles of lean construction: • efficiency • best value • ensuring the work environment is clean and safe • improving planning • continuous review and improvement. Aims of lean construction: • eliminating waste and errors through reduction, recycling and repurposing • improving work planning and forward scheduling • identifying the processes that deliver best value • eliminating activities that do not add value • ensuring the working environment is clean, safe and efficient • continuous improvement • just-in-time deliveries. Advantages and limitations of lean construction. The techniques aimed at maximising value and minimising waste within the building services industry including just in time (JIT) deliveries, reducing errors and recycling.
	Skills CSB
5.7 Waste management legislation	Waste management legislation: • Waste Electronic and Electrical Equipment (WEEE) • F Gas. Key requirements and duty of care of waste management legislation including which materials may contain hazardous waste. Key requirements include: • waste carrier's license • separation and waste • exemptions.

5.8 Waste management	Transportation and disposal methods for waste, including: • general and specialist disposal • use of licensed disposal companies • use of registered waste carriers. Plans to reduce use of pollutants in construction projects including: • reduction of high carbon emissions • reducing land contamination • correct waste disposal. The areas a site waste management plan SWMP covers: • who is responsible • what types of waste • how it will be managed • approved contractor • how waste is measured. Reduce, reuse, recycle (3Rs). Waste segregation.
	Skills EC2 EC3 EC5

5.9 Energy production and energy use	Types of energy produced including:
	• nuclear
	• heat and power combined
	• fossil fuels including alternative methods such as:
	    • wind
	    • ground
	    • solar
	    • hydroelectric
	and their impact when used (i.e. availability, impact on environment, costs).
	
	Reasons for choosing energy sources, for example, localism/regionalism and the advantages and disadvantages of each method.
	
	What hydrogen is and the methods for producing it, with pros and cons:
	• reforming methane vs electrolytes (cost vs CO2).
	
	CO2 emissions, including projections for the next 30 years for:
	• Bio-methane
	• Biomass
	• Carbon capture and storage.

	Skills EC6

5.10 Renewable energy and energy conservation	Renewable energy technologies include: • 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 solutions include: • rainwater and grey water recycling • heat recovery • energy efficient lighting • electric vehicle charging points • appliance efficiency ratings. The basic operating principles of renewable energy technologies and energy conservation solutions. The main components forming renewable energy technologies and energy conservation solutions. Advantages and limitations of renewable energy technologies and energy conservation solutions.
	Skills MC6 DC1
5.11 Digital technologies	The environmental technologies that could be used, including devices connected via the Internet of Things (IoT) to include: • building services system controls • smart meters • hubs/routers control and monitoring systems – Smart meters • building management system • automated controls • movement sensors. 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 advantages and limitations of control and monitoring systems.
	Skills MC6 DC1 DC6

<table>
<tr><th colspan="2">6. Construction measurement principles</th></tr>
<tr><th>Content</th><th>Range and amplification</th></tr>
<tr><td rowspan="2">6.1 Accurate and appropriate measurement</td><td>Accurate measurement of:
materials quantities
materials costs
labour costs
activity time
overall time
setting out sites
positioning BSE components.
The benefits of accurate measurements to:
contractors
the client/customer
profitability
project success.
Using plans or physical dimensions to help plan activities and measure quantities.

Obtaining accurate measurements to calculate quantities and costs.

The benefits of accuracy in site/location/areas measurements to accurately calculate material quantities to enable accurate costing of construction projects.

Use of different costing techniques to suit the activity or project being undertaken, including advantages and limitations for each type.

Calculating costings using costing techniques, including:
job costing
batch costing
activity costing
life cycle cost analysis.
The implications of not having accurate measurements – in terms of costs, time and safety.

The impacts of inaccurate values on overall outcomes, including:
small angular errors
rounding up and down multiple calculations
recording of decimal places.</td></tr>
<tr><td>Skills CSC MC1 MC9</td></tr>
</table>

6.2 Standard units of measurement and measurement techniques	The types of units of measurement: • mm millimetres • cm centimetres • m metres • km kilometres • g gram • kg kilogram • tn tonne • ltr litres • m^2 square metres • m^3 cubic metres • s time • N/m^2 pressure • N force. How units of measurement are applied and used in construction projects, including methods of obtaining data using measurement techniques in differing situations. Measurement techniques: • approximation • use of measuring equipment including tapes • wheels • callipers • rules • lasers • surveying equipment. Differing situations: • height • length • distance • area • volume • weight • mass • quantity • CO2 emissions • insulation. Methods of calculating units of measurement from data sources and measurements for differing situations.
	Skills MC1 MC2 MC3 MC4

6.3 Measurement standards, guidance and practice	How to use and calculate standardised scales for recording or displaying measurements, including measurement rules. How tolerances are applied and the implications of not meeting tolerances. How to calculate actual dimensions of building features using scales from drawing measurements. Drawing sizes used to display information and detail: • A0 • A1 • A3 • A4 How to use common scales for various drawing types: • 1:1 Rod, full scale drawing • 1:2 half scale, assembly drawing • 1:5,1:10 Detail drawings • 1:20,1:50,1:100, 1:200 floor plans, elevations, sections • 1:200, 1:250, 1:500 Site plans/block plans1:1250 1:2500 location plans
	Skills EC1 MC1 MC3 MC4

7. Building technology principles	
Content	**Range and amplification**

7.1 Construction methods	Types of traditional and modern construction methods including historic buildings pre and post 1920:
	• modular
	• onsite
	• off site
	• 1st fix
	• 2nd fix
	• computer-controlled manufacturing robots
	• large-scale 3D printers
	• On-site:
	    • timber frame
	    • brick and block
	    • container straw bale
	    • robotics
	• Off-site:
	    • pre-assembled
	    • precast
	    • modular
	    • panel systems
	    • 3D printing.
	
	Applications, benefits and limitations and procedures of both traditional and modern construction methods including the use of robotics during the construction process.
	
	Renovation and refurbishment:
	• upgrades
	• cosmetic
	• structural changes.
	
	Maintenance:
	• fabric services
	• upgrades.

7.2 Key content and required notifications of UK Building Regulations and Approved Documents	The key content and purpose of each of the current UK Building Regulations approved documents/parts in relation to renovations and construction of buildings. Approved Documents: • part A – structure • part B – fire safety • part C – site preparation and resistance to contaminants and moisture • part D – toxic substances • part E – resistance to the passage of sound • part F – ventilation • part G – sanitation, hot water safety and water efficiency • part H – drainage and waste disposal • part J – combustion appliances and fuel storage systems • part L – protection from falling, collision and impact, • part K – conservation of fuel and power • part M – access to and use of buildings • part P – electrical safety • part Q – security • part R – physical infrastructure for high-speed electronic communications networks • part S – infrastructure for charging electric vehicles.
	Skills CSB EC5
7.3 Building standards	Current British Standards including: • waste management • BIM • fire safety. International Standards including: • standards for structures • materials • sustainability. Common minimum standards used for public sector projects. Their purpose and benefits (e.g. guidance, pushing up standards etc.) in construction and renovation.
	Skills CSB EC5
7.4 Manufacturers' instructions	Type and purpose of manufacturers' instructions: • installation • operation • maintenance • safe methods of recycling • disposal instructions.
	Skills CSA

7.5 Building structure, fabric and forms of construction	Current forms of construction and their use for both built environment and civil engineering structures. The different types of building materials and building fabrics and structures including the implications for the application, installation and maintenance of Building Services Engineering systems, and the suitability of supports and fixings. Structure: • timber framed • steel framed • masonry • concrete. Substructures: • types of foundations • basements • retainer wall. Superstructure: • roofs • walls • floors • partitions • windows • doors • frames. Infrastructure: • roads • sewage systems • railways • bridges. Internal/external walls: • cavity • solid • infill • stud • openings vertical and horizontal • damp proof • weather tight • preventing water ingress and allowing for egress (weep holes). External work: • paving • boundaries • drainage • parking (finished surfaces, sub-base materials).

	Fabric: • timber • cladding • masonry • fenestration • plaster boarding. Supports and fixings related to forms and building services components including: • wall plugs • toggles • anchor bolts • cavity fixing • self-drive plaster board fixings • wood screws • machine screws • threaded stud • nails • chemical solutions.
7.6 Approved documents and guidance for penetrating building structure and fabric	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. 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.
	Skills CSA EC5

8. Construction information and data principles	
Content	**Range and amplification**
8.1 Data	Apply key elements of data, from different sources used, to inform construction and building services processes: • accuracy • generalisation • interoperability • level of detail • metadata. How to obtain information from different sources and how to analyse this information to make accurate and informed decisions: • design and construction processes • Building Information Modelling (BIM) • 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 different sources that can be used to: • understand behaviour • assess performance • improve market competitiveness • allocate resources • determine/calculate costs.
	Skills MC5 MC6 MC9 EC4 EC5 DC3 DC4

8.2 Sources of information	Interpreting types of information and data sources used within construction and building services projects including: • product data • manufacturer’s specifications • client’s specifications • Common Date Environment • Building Information Modelling (BIM) • drawings • plans • Gantt chart • critical path networks • certification and commissioning data • test data schedules • condition reports • carbon emissions. Using data sources to calculate outcomes or costs. Using data to plan and schedule tasks, activities and projects. Advantages and limitations of each of the types of information.
	Skills CSC EC1 EC2 EC3 DC1 DC3 MC2 MC5 MC10
8.3 Data management and confidentiality	Current legislation including GDPR and organisational procedures that are used to manage data and increase confidentiality including: • encrypted data • virus protection software • software updates • firmware updates • GDPR requirements • business procedures. Cyber security purpose and best practice, including: • staff training to avoid phishing attacks • use of strong passwords • use of regular back-ups • use of secure data transfer using cloud-based systems • avoiding use of pen drives. Data storage requirements, physical and virtual, in relation to security and protection and how systems and procedures help to prevent common threats, for example: • cyberattacks • malware • Trojans • data loss • ransomware • data recovery.
	Skills DC5

8.4 Drawings, circuit diagrams and schematics	Interpreting Building Services Engineering information and data using scale, abbreviations, and BS symbols. Drawings, circuit diagrams and schematics include: • common symbols • circuit diagram • wiring diagram • layout drawings • schematic diagrams • building plans • site plans • schedules. The purpose of each type of drawing or diagram. The drawing conventions, symbols and terminology needed to aid interpretation. Common symbols (including methods to denote types, gangs, poles and ways): • switches • socket-outlets • isolators • fused connection units • consumer units (CU) • luminaires • valves/stop cocks • appliance isolator • reducer • elbows • supply types • pump circulator • fan.
8.5 Programming and set up of digital systems using various IT resources	Awareness of the digital systems available for design and modelling of construction projects, including: • BIM • CAD. IT resources including: • modelling and design programmes • mobile technologies • computer • CAD catalogues.
	Skills DC1 DC6

<table>
<tr><th colspan="2">9. Relationship management in construction</th></tr>
<tr><th>Content</th><th>Range and amplification</th></tr>
<tr><td rowspan="2">9.1 Stakeholders</td><td>The different roles of the following stakeholders in construction projects:
• client
• client representative team
• construction team
• suppliers
• community
• end user.</td></tr>
<tr><td>Skills CSD EC1</td></tr>
<tr><td rowspan="2">9.2 Roles, expectations, and interrelationships</td><td>The expectations and interrelationships of all stakeholders throughout the construction project delivery, at design stage, through construction, to handover and in use, including:
• hierarchy of project management
• promoting good relationships across the project
• cost control measures
• time management methods
• handover processes
• public relations – to include behaviour of employees outside of work hours
• follow up and review.

Project management roles include:
• architect
• clerk of works
• quantity surveyor
• contacts manager
• site manager
• project manager.</td></tr>
<tr><td>Skills CSD EC1</td></tr>
<tr><td rowspan="2">9.3 Collaborative working to project delivery and reporting</td><td>The importance of a collaborative approach to project delivery and reporting and providing information at various stages in the development. How this is applied in practice (with the use of BIM and workflow software packages as well as face to face methods).</td></tr>
<tr><td>Skills CSC CSD EC1 EC2 EC3 DC3</td></tr>
</table>

<table>
<tr><td>9.4 Customer service principles</td><td>The basic principles of good customer service and the benefits of good customer service including:
• repeat business
• good reputation
• satisfied customers and employees
• increased market share.

Customer service principles include:
• good product knowledge
• building trust
• meeting timescales
• good communication
• efficiency
• honesty
• integrity.</td></tr>
<tr><td></td><td>Skills CSC EC1 EC6</td></tr>
<tr><td>9.5 Team work in relation to team and project performance</td><td>The importance and advantages of good team work to team and project performance, and the consequences of poor teamwork and how it impacts on a construction project such as the effects of productivity and efficiency.

Project performance includes:
• efficiencies
• morale of staff, creativity
• accountability
• open communication
• common goals

Consequences of poor teamwork include:
• conflict and tension
• low engagement
• lack of trust.</td></tr>
<tr><td></td><td>Skills EC2 EC6</td></tr>
<tr><td>9.6 Team dynamics</td><td>Qualities and characteristics of good team dynamics, including, what is expected of team members, team structure, what qualities are needed and how these qualities are demonstrated.

Good team dynamics include:
• knowledge of trade/business/product/service
• accountability
• cooperation
• trust
• support
• reliability
• effective communication
• active participation
• adaptability.</td></tr>
<tr><td></td><td>Skills EC2 EC6</td></tr>
</table>

<table>
<tr><td>9.7 Equality, diversity and representation</td><td>Current equality and diversity legislation and the protected characteristics detailed under:
• the Equality Act
• Employment Rights Act
• Human Rights Act and trade unions, including its application in the workplace.

How to promote equality, diversity and inclusion in the workplace.

Equality, diversity and representation in the workplace includes:
• age
• disability
• gender reassignment
• marriage and civil partnership
• pregnancy and maternity
• race
• religion or belief
• sex
• sexual orientation.</td></tr>
<tr><td rowspan="2">9.8 Negotiation techniques</td><td>Methods of negotiation and how they are used within the construction industry to:
• acquire land
• obtain planning permission
• award contracts
• negotiate change orders
• negotiate material costs
• negotiate time extensions
• resolve disputes.

Negotiation techniques include:
• distributive negotiation or win-lose approach
• lose-lose approach
• compromise approach
• integrative negotiation or win-win approach.</td></tr>
<tr><td>Skills EC6</td></tr>
<tr><td rowspan="2">9.9 Conflict management techniques</td><td>Conflict management techniques include:
• preventative measures
• compromise
• problem solving
• avoiding
• competing
• forcing
• alternative dispute resolution (informal discussions, mediation, conciliation, arbitration)
• common reasons for conflicts.

Using digital methods to resolve conflict including the use of BIM for controlling conflict before it escalates.

Procedures when construction projects change/alter.</td></tr>
<tr><td>Skills CSD EC6</td></tr>
</table>

<table>
<tr><td rowspan="2">9.10 Methods and styles of communication</td><td>The styles and methods of communication, type of communication and suitability for different situations that may arise throughout a typical construction project from concept to handover.

Digital project management platforms and how these can be used to communicate as part of the construction project teams.

Methods of communication include:
• verbal
    • pitch and tone
    • questioning types open/closed
• non-verbal
    • body language
    • eye contact
    • facial expressions.

Styles of communication include:
• formal
• informal.

Types of communication include:
• face to face
• email
• letter
• telephone
• walkie talkie
• text message
• social media
• drawn information.</td></tr>
<tr><td>Skills EC1 EC3 EC6 DC1 DC3</td></tr>
<tr><td rowspan="2">9.11 Employment Rights and Responsibilities (ERR)</td><td>The current employment rights, their implications and the responsibilities of employees and their employer.

Employment Rights include:
• wage rules (minimum wage, pension)
• time off (holiday, parental leave, rest breaks etc.)
• equal rights (against harassment and discrimination)
• health and safety and welfare
• access to representation in times of grievance (trade union representation/independent representation).

Responsibilities include:
• employer to employee – work, pay, health, welfare and safety provided
• employee to employer – working to contract
• complying with health and safety and welfare
• confidentiality
• reasonable behaviour as set out in the company handbook.</td></tr>
<tr><td>Skills EC5</td></tr>
</table>

9.12 Ethics and ethical behaviour	Ethics and ethical behaviour of individuals and corporations including the advantages they bring to project delivery. Ethical behaviour in the construction industry includes: • honesty • integrity • equality • loyalty • fairness • caring • respect • adherence to laws • commitment • reputation • accountability.
	Skills CSD
9.13 Sources of information	How sources of information suitable for the construction/BSE industry contribute to the stakeholder experience by: • sharing ideas and knowledge • providing advertising and promotion opportunities • getting customer reviews and feedback. Sources of information include: • internet • TV • radio • hoardings • local business networks • social media networks.
	Skills CSD

10. Digital technology in construction	
Content	**Range and amplification**
10.1 Internet of Things	The use of technology to capture data in a completed building and how this data is used for the purpose of future manufacture and delivery. The use of technology and the Internet of Things to control the environment conditions, lighting and security in completed buildings. The different uses of technology connected to the Internet of Things and their use and role in the construction industry such as: • increasing productivity • assisting just in time • asset management • maintenance. Internet of Things include: • smart technology • smart/automated building systems • smart learning • artificial intelligence (AI) • building control systems • building management systems • smart applications • security systems and monitoring systems.
	Skills DC1 DC3 DC5
10.2 Digital engineering techniques	Current Digital engineering techniques and their application in the construction industry, including: • Simulation – structural analysis • Animation – visualisation of structural behaviour • Surveying – laser level, measuring and drones • CAD modelling – (2D drawings, 3D modelling) artist impression.
	Skills MC6 DC1 DC2 DC6

10.3 Opportunities for the use of technology	The benefits of using current technologies from other industries including: • accuracy • accessibility • efficiency • reducing risk. How current technologies from other industries can be adapted for use in the construction and the built environment. Current technology includes: • machine manufacturing through robotics • CADCAM • computer modelling • smart technologies.
	Skills MC6

11. Construction commercial/business principles	
Content	**Range and amplification**
11.1 Business structures	Typical business structures in the built environment and construction industry including advantages, limitations and key differences. Business structures include: • sole trader • partnership • limited company (PLC. Ltd.) • small and medium enterprises (SMEs) • not-for-profit organisations • not-for-profit organisations/community interest company (CIC), charities • franchise • Direct Labour Organisation (DLO). Key differences include: • ownership • management of the company • legal status • liability • advantages/disadvantages.

11.2 Business objectives	The business and corporate objectives used to measure performance of an organisation in the construction industry:
	• Methods of funding:
	  ◦ self-funding
	  ◦ corporate
	  ◦ partnerships
	  ◦ local and central government
	  ◦ crowd funding
	• Financial:
	  ◦ private organisations (profit, growth and innovation, market leadership)
	  ◦ not-for-profit (value for money, increased access, reduced poverty)
	• Calculating targets for performance
	• Social:
	  ◦ private organisations (providing employment)
	  ◦ not-for-profit (providing housing, healthcare, services and education)
	• Organisational culture:
	  ◦ beliefs
	  ◦ behaviours and ethical values
	  ◦ aligning with business objectives
	• Quality – measurable objectives, including use of quality marks, ISO, etc.
	• Innovation – allows for generation of ideas, innovation activities and goals aligning with business objectives

	• Compliance – regulatory compliance with (external) rules and internal controls built into objectives • Sustainability – sustainability embedded into business objectives, from energy-efficient construction to eco-friendly use of materials.
	Skills MC2 MC6 MC9
11.3 Business values	Fundamental business values and how these can be achieved by: • the practising of ethics and transparency • codes of conduct • commitment to the customer • collaborative working. Business values include: • financial stability • customer service • care for life.
	Skills CSD
11.4 Principles and examples of corporate social responsibility	Approaches to corporate social responsibility (CSR): • incorporating sustainable development into a company's business model • positive impacts on social, economic and environmental factors • use of local resources – local trades, local suppliers and locally produced materials • community design – community-led designs, inclusive design. Examples of CSR in the construction industry: • design • responsible purchasing • career management • use of local operatives/trades/suppliers and local sustainable materials • sustainable initiatives.
11.5 Principles of entrepreneurship and innovation	Principles of innovation and entrepreneurship: • solution provider • vision • viable product/service • capital • growth and marketing • research • priorities. The role principles of innovation and entrepreneurship plays in the construction industry, such as: • improved product service • increased growth/profit • advancements in industry.

11.6 Measuring success	How organisations in the built environment and construction industry use benchmarking, review, evaluation and feedback when measuring business success. Benchmarking includes: • Key performance indicators (KPI's) • standard setting • target setting • input • output • process.
	Skills CSA
11.7 Project management	The principles of project management, ensuring all objectives are measurable and achievable, including SMART technique. Project management includes: • effective planning • setting clear goals and objectives • defining roles and responsibilities • setting realistic milestones.
	Skills CSC
11.8 Quality management	The quality management systems and techniques used in business: • self-assessment • internal audit • external audit • quality control • quality improvement • ISO 9000 series. The application of each system and the purpose of quality management systems – to maintain the standard or quality of the work in a consistent manner.
	Skills CSD

12. Building Services Engineering systems	
Content	**Range and amplification**

12.1 Building Services Engineering systems	The layout and basic components included in a range of BSE systems. What these systems are used for and when they are used.
	
	The key differences in operation and advantages and disadvantages of each system type.
	
	Integration between systems including common skills and components.
	
	Building Services Engineering systems include:
	• Air conditioning systems:
	  • cooling air
	  • heating air
	  • humidification
	• Electrotechnical systems:
	  • power
	  • data
	  • lighting
	  • control
	  • heating
	  • appliances
	• Gas systems:
	  • boilers
	  • fires
	  • cooking appliances
	• Heating systems:
	  • boilers/heat source
	  • radiators
	  • underfloor heating pumps
	  • controller
	  • zone valves
	• Plumbing systems:
	  • cold water
	  • hot water
	  • sanitation
	  • drainage
	  • rainwater systems
	• Protection systems:
	  • intruder alarms
	  • surveillance systems
	  • fire alarms
	  • access control
	• Refrigeration systems:
	  • chilled water
	  • cooling air
	• Ventilation systems
	  • mechanical ventilation
	  • non-mechanical ventilation.

	Skills CSA CSB
12.2 The potential effects on building performance during installation, commissioning and decommissioning of BSE systems	The effects of installation, commissioning and decommissioning of all or part of a BSE system, including impact on: • environment • other trades • users, including loss of services or essential systems. Building performance to include: • lighting • power • heating • cooling • ventilation • toilet facilities • water • access • egress • security • protection systems • data • internet.
12.3 Mechanical principles of components	Basic mechanical principles of BSE mechanical components, detailing their characteristics, function within the system, and implications to the system of component failure. Components include: • fans • pumps/circulator • burners/boilers/heat source • chillers • heat pumps • controllers.
12.4 Electrotechnical principles of components	Electrotechnical principles of components including their characteristics, applications and functions. Advantages and disadvantages of each component and implications for the system if components fail. Components include: • flat ton and cpc cable • steel-wire armure cable • flexible cable • socket-outlets • switch types • isolators • switches for mechanical maintenance • luminaires • conduit • trunking • tray.

<table>
<tr><td>12.5 Electrical supply</td><td>The different types of electrical circuit and supply.

Electrical supply includes:
• single-phase circuits
• three-phase circuits
• three-phase and neutral
• balanced supplies.

The different voltage levels achieved between circuit conductors in electrical supplies in a range of buildings:
• 230 V
• 110 V
• 400 V
• extra-low voltage
• low-voltage
• reduced low-voltage.

The benefits of having different voltage supplies and the voltage levels for BSE systems and buildings.

Buildings include:
• domestic
• commercial
• industrial.</td></tr>
<tr><td>12.6 Earthing arrangements</td><td>The different types of earthing arrangements and the attributes of each system.

Earthing arrangements:
• TN-C-S (PME) systems
• TN-S systems
• TT system.

The nature of the earth return path in each system and what system components are included in each arrangement making the earth fault loop path.

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

Hazards include:
• electric shock
• fire
• explosion
• diverted neutral current
• potential differences.

Services include:
• gas
• water
• oil
• insulated
• extraneous.</td></tr>
</table>

12.7 Cables, accessories and equipment used in older electrical installations	The common cable types and sizes (metric, imperial) for a range of circuits including: • lighting • socket-outlets • heating. 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 them. How these have been superseded and the components they have been replaced with, and the implications for BSE system installation and maintenance. Cables, accessories and equipment include: • lead sheathed cable • Vulcanized India Rubber (VIR) insulated cable • past cable colours • BS 3036 • rewireable fuses • non-fire rated consumer units/distribution boards.
	Skills MC2 MC4

12.8 Pipework and ductwork, components and systems	The various types of components that make up both pipework and ducting systems used in BSE systems and how the selection of each affects the performance of the system.
	
	Ductwork includes:
	• flexible ducting
	• metal ducting
	• fabric ducting
	• cardboard ducting.
	
	Components include:
	• ductwork accessories:
	    • VCD, VAV/CAV
	    • fire dampers
	    • attenuators
	    • heating coils
	    • cooling coils etc.
	• air terminals:
	    • grilles
	    • louvres
	    • extract
	    • valves etc.
	• electrical components:
	    • electrical isolators
	• pipework accessories:
	    • emergency control valves
	    • stop taps and key isolation valves

	• radiator valves • immersion heaters • room thermostats • timer/programmer. Systems include: • gas • plumbing • air conditioning • refrigeration • heating • drainage • sanitation.

13. Maintenance principles	
Content	**Range and amplification**
13.1 Types of maintenance	General types of maintenance, their key differences and which is most suitable for different situations. Types of maintenance: • planned preventative maintenance • reactive maintenance. Advantages and limitations of the two types of maintenance and situations where each would be applied.
	Skills CSA
13.2 Maintenance plans	The typical requirements of maintenance plans, either as planned or reactive, their content and typical maintenance tasks for each type of BSE system. Maintenance plans for: • heating system service • boiler service (gas engineer) • water services • firefighting equipment • fire detection and smoke alarm systems • intruder alarm system • electrical installation systems • ventilation system • air conditioning system • drainage • communications • data.
13.3 Typical timeframes between maintenance tasks	The frequency and purpose for completing maintenance tasks on all BSE systems. The requirements for commercial buildings and 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	The reference documents and forms needed when completing both planned and reactive maintenance, including: • manufacturer’s instructions • maintenance checklists • servicing logbooks • maintenance schedule • job sheets • condition reports • operation and maintenance manuals. Typical information included in and purpose of an operation and maintenance (O&M) manual: • user instructions • maintenance and care instructions • recommended spares • emergency procedures • certification.
	Skills EC4
13.5 Actions required when faults cannot be rectified	The actions required when faults cannot be rectified on some systems, including: • informing the customer • arranging secondary services until primary are back in service • making systems safe. Systems include: • electrical systems • plumbing systems • heating systems • protection systems • ventilation systems. The implications on the customer when faults cannot be rectified, including: • time • costs • downtime of system • loss of income • increased hazards • loss of services.
	Skills MC9 MC10 EC1 EC3 EC4

14. Tools, equipment and materials	
Content	**Range and amplification**
14.1 Methods used to ensure tools, equipment and materials are fit for purpose	Tools, equipment and materials are fit for purpose and the required checks that are undertaken to ensure this. The methods to ensure tools and equipment are fit for purpose and the required checks that are undertaken to ensure this include: • Portable appliance testing (PAT) • calibration of instruments • cleanliness checks • daily checks including visual inspection and operation check • condition reports • asset registers • free from damage. Calculating and identifying suitable tolerances in relation to instrument accuracy. The methods to ensure materials are fit for purpose and the required checks that are undertaken to ensure this include: • fit for purpose • associated hazards • quantity • specialist requirements • free from damage. The procedure that should be applied for tools and equipment that fail safety checks. The safe isolation procedure when replacing attachments to power tools, to include: • drill bits • cutting blades. The methods of safe supply for electrical tools and equipment on site including colour identification system, to include: • battery-powered • 110 V • 230 V.
	Skills MC1

14.2 Maintenance of tools, equipment and materials	The importance of correct tool maintenance, including: • safety • prolonged tool life • accuracy. The methods of maintaining a range of tools used in BSE, including: • safe storage • correct storage • greasing • sharpening • cleaning.

Electrotechnical Engineering

Level	3
GLH	650
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 while using a range of materials, methods and techniques. Learners will further develop their Core knowledge and understanding of, and skills in: • Health and safety practices associated with carrying out electrotechnical systems engineering • Installation methods and termination of connections • Systems and products used in electrotechnical engineering • Analysing and using information to and from electrotechnical systems • Removal processes as part of system decommissioning. Note: Completion of the core and this occupational specialism provide threshold competence for entry into industry but does not provide full proof of occupational competence.
Learner preparation	Learners may be introduced to this specialism by asking themselves questions such as: • What does an electrotechnical engineer do? • Who are the key stakeholders that 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? • What skills are required in the role of an electrotechnical engineer?
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: 1. Install electrotechnical systems 2. Commission electrotechnical systems 3. Maintain electrotechnical systems 4. Decommission electrotechnical systems.
Maths, English and Digital skills	Completion of this specialism will give learners the opportunity to develop their Maths, English and digital skills. Where applicable, this information is included under the knowledge outcome, shown in square brackets.

Link to prior learning (Common Core)	Learners will build on their core knowledge and understanding by focusing on specialised knowledge required to work in and around electrotechnical systems. Underpinning knowledge and understanding have been referenced in relation to the relevant knowledge outcomes.
Assessment method	Practical assignment.

Outcome 1 – Electrotechnical common knowledge criteria
Learners will gain knowledge and understanding of the following content areas: Tools, equipment and materials (K1.1 – K1.2) Electrical installation (K1.3 – K1.10) System installation (K1.11 – K1.13) System commissioning (K1.14 – K1.16) System maintenance (K1.17 – K1.20) System decommissioning (K1.21 – K1.22)

Tools, equipment and materials (K1.1 – K1.2)	
Knowledge criteria	**Range and amplification**
K1.1 Tools and equipment used for installation	Tools required related to the requirements of the job specification – identification of the range of both general and specific tools required. Selection of 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 the specific task. 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 • Mineral Insulated (MI) kit • stocks and dies.
	Underpinning Core Knowledge: C14.1
K1.2 Operation and handling requirements	Techniques for the 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.
	Underpinning Core Knowledge: C14.2

Electrical installation (K1.3 – K1.10)	
Knowledge criteria	**Range and amplification**
K1.3 Principles of electrical circuits and loads	How different circuit arrangements affect voltage and current behaviour. Control of loads by circuit arrangement and the reasons why particular circuit arrangements are selected. Direct Current (DC) 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 behaviour and energy losses. How magnetism is induced, and the effects of magnetism. How different types of loads 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. Circuits: • ring-final • radial • lighting • series • parallel • Alternating Current (AC) • DC • magnetic effect

	• temperature effect • voltage drop • single phase • three phase. Loads: • AC • DC • resistive • inductive • capacitive • power factor • true power • apparent power. [MC5, MC6]
	Underpinning Core Knowledge: C2.5, C12.5
K1.4 Assessment of general characteristics outlined in national standards	Assessing general characteristics of installations such as supply types, and earthing arrangements such as: • TT • TN-S • TN-C-S. How neutral current diversion can appear on earthing systems. Broken protective earthed neutral (PEN)protection. 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. Terms relating to renewable energy technologies: • prosumer installation • island mode • load curtailment • load shedding. The importance of fully isolating a property when systems such as solar Photovoltaic (PV) or battery storage are fitted. [EC5]
	Underpinning Core Knowledge: C12.5, C12.6, C14.1

K1.5 Application of the fundamental principles of national standards	Refer to the national standards and the requirements of the Electricity at Work Regulations, building regulations and BS 7671:2018+A3:2024 for the design, installation, inspection and testing of electrical systems and equipment. Interpret and implement fundamental principles of BS 7671:2018+A3:2024 including how they are detailed in Parts 4-6 of the standard. Use of information in the Appendices of BS 7671:2018+A3:2024 and Guidance Notes to formulate installation design and protection, giving consideration to the fundamental principles. [EC5]
	Underpinning Core Knowledge: C1.1, C7.2, C7.3
K1.6 Special installations and locations specified in national standards	Refer to Part 7 of the latest edition of the requirements for electrical installation (BS 7671:2018+A3:2024 – Requirements for Electrical Installations, IET Wiring Regulations) and Institution of Engineering and Technology (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. [EC5]
	Underpinning Core Knowledge: C7.2
K1.7 Design concepts of installations specified in national standards	Refer to the latest edition of the requirements for electrical installation (BS 7671:2018+A3:2024 – Requirements for Electrical Installations, IET Wiring Regulations) on-site guides and IET Guidance Notes 1–8 for information and support for protection and safety within electrical installations as specified in the national standards. Interpret requirements and relate these to different circuit types and accessories that form typical electrical systems. Select the correct protection methods and devices for typical systems, including those required for protection, isolation control and switching. [EC5]
	Underpinning Core Knowledge: C1.7, C7.2

<table>
<tr><td rowspan="2">K1.8 Methods of selecting and installing wiring systems</td><td>How to ensure that electrical wiring systems are selected and installed in accordance with current legislation and industry practices and are fit for purpose and safe to be put into service.

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
• auxiliary.</td></tr>
<tr><td>Underpinning Core Knowledge:
C2.5, C12.4, C12.7</td></tr>
<tr><td rowspan="2">K1.9 Methods of selecting and erecting electrical installation components</td><td>Consulting IET guidance documents in the installation of all electrical circuits and components, making sure that the installation meets the current legislation and industry practices.

Factors that affect suitable circuits and components, including their protection and longevity.</td></tr>
<tr><td>Underpinning Core Knowledge:
C12.4, C12.5</td></tr>
<tr><td rowspan="2">K1.10 Types of lighting and luminaire</td><td>How height and spacing of luminaires affect illumination values.

Application of different lighting, lamp types and luminaires used for different effects including:
• efficacy
• energy efficiency
• lumens
• regulatory lux levels
• colour rendering.</td></tr>
<tr><td>Underpinning Core Knowledge:
C12.4, C2.8</td></tr>
</table>

System installation (K1.11 – K1.13)	
Knowledge criteria	**Range and amplification**
K1.11 Methods of cable installation and wiring system supports	How to install cables and containment in line with current legislation and industry practices. Considerations when installing cables such as building regulations, manufacturer's instructions, IET guidance and British Standards. Cable installation and wiring system supports. • single and multicore thermoplastic cable • Steel wire armoured (SWA) multicore armoured cable • Mineral insulated copper cable (MICC) • Fire performance (FP200)- Fire resistant cable • flexible cable • data cable Category (CAT5a/6) • cable tray • cable conduit (steel and Polyvinyl chloride PVC) • cable trunking • ladder racking • cable basket • cable cleats • clips • cable hangers.
	Underpinning Core Knowledge: C7.2, C7.3, C7.4, C12.4
K1.12 Methods of terminating cables	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 given to building regulations, manufacturer's 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 are secure: • cable glands • grips • clamps.

K1.13 Methods of terminating and connecting conductors	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 given to 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 suitable for external influences and are secure. Appropriate methods should be selected depending on the type of maintenance expected including access. Terminating and connecting: • screwed • crimped • compression • soldered • maintained • non-maintained • insulation displacement.
	Underpinning Core Knowledge: C7.2, C7.3, C7.4

System commissioning (K1.14 – K1.16)	
Knowledge criteria	**Range and amplification**
K1.14 Inspections for initial verification of electrotechnical systems	Standard procedures and processes to undertake inspections, including the items to be inspected when carrying out initial verification in accordance with BS 7671:2018+A3:2024 and IET Guidance Note 3. Consideration should also be given to providing the required information including operation and maintenance (O&M) manuals.
	Underpinning Core Knowledge: C1.6
K1.15 Testing for electrotechnical systems	Tests to be carried out on electrical installations in accordance with BS 7671:2018+A3:2024 and IET Guidance Note 3. Identify the appropriate instrument for each test to be carried out in terms of: • the instrument being 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. Know 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 7671:2018+A3:2024 and IET Guidance Note 3. [DC1, DC5, DC6]
K1.16 Equipment adjustments as required by installation standards to ensure correct function	Standard procedures and processes 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. To include the adjusting of settings as required (fan running times, overloads). Know how this information is recorded and conveyed to stakeholders during the handover process.
	Underpinning Core Knowledge: C4.12, C9.1

<table>
<tr><th colspan="2">System maintenance (K1.17 – K1.20)</th></tr>
<tr><th>Knowledge criteria</th><th>Range and amplification</th></tr>
<tr><td rowspan="2">K1.17 Types of electrotechnical system maintenance</td><td>Legal requirements relating to planned and preventative maintenance (PPM), responsibilities for undertaking maintenance regimes.

Advantages and limitations of PPM and reactive maintenance.

Requirements for completing documentation and updating O&M manuals.

System maintenance:
PPM
reactive maintenance.</td></tr>
<tr><td>Underpinning Core Knowledge:
C4.11, C7.4, C12.4, C13.1, C13.2, C13.4</td></tr>
<tr><td rowspan="2">K1.18 Fault-finding and rectification techniques</td><td>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.

Fault-finding techniques:
identification of symptoms
collection and analysis of data
use of sources/types of information (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.
[MC2]</td></tr>
<tr><td>Underpinning Core Knowledge:
C13.5</td></tr>
</table>

K1.19 Maintenance requirements for different building types and locations	Regulations concerning set systems to put in place in relation to different types of premises. Building types: • private • commercial • house in multiple occupation (HMO) • residential. Some types of buildings (hospitals, chemical plants, paint stores) are covered by specific, specialist regulations and control measures.
	Underpinning Core Knowledge: C1.1, C7.2, C7.3
K1.20 Maintenance of older systems and installations	Identification of older systems that may not be compliant with current regulations and reporting on condition and suitability for continued use.
	Underpinning Core Knowledge: C12.6

System decommissioning (K1.21 – K1.22)	
Knowledge criteria	**Range and amplification**
K1.21 Ways of making systems safe to decommission	Isolating system from the supply source or outgoing service, turning off the electrical supply. Handling materials to protect their integrity and safety during decommissioning. Removing pre-installed components from electrical installations. Reconfiguring electrical installations during the decommissioning process. Categorising waste produced during the decommissioning process. Using construction materials to make good the building fabric following installation component removal.
	Underpinning Core Knowledge: C1.7, C5.7, C5.8, C7.5
K1.22 Methods of identifying potential issues before decommissioning systems	Methods including reviewing O&M manuals, and consultation of component data sheets and drawings. Benefits of devising a timely plan when decommissioning systems.
	Underpinning Core Knowledge: C6.3, C8.2, C8.1, C8.4

<table>
<tr><th colspan="2">Outcome 2 Install electrotechnical systems (S2.1 – S2.14)</th></tr>
<tr><th>Performance criteria</th><th>Range and amplification</th></tr>
<tr><td>S2.1 Assess risk associated with tasks</td><td>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 the system being installed but may include for example whether any specialist equipment is needed.

Consideration should be given to recording of risk assessment findings in line with regulations as well as the responsibilities of employees versus employers.</td></tr>
<tr><td>S2.2 Collect and collate information required to complete tasks</td><td>Interpret data from sources in order to correctly carry out installation processes.

As part of this, the importance of 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.

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

Information:
manufacturer’s instructions
Building Regulations
drawings
British Standard European Norm (BS EN) standards
data sheets.
[EC4, EC5, MC4]</td></tr>
<tr><td>S2.3 Select tools, equipment and materials to complete tasks</td><td>Select the correct materials and hand/power tools or specialist equipment required to complete work activities, taking into consideration safe use of the equipment and suitability of tools and equipment matched to the specific task.

Tasks:
installing wiring
containment systems
connecting equipment.</td></tr>
</table>

S2.4 Design installation suitable for client's specification and in accordance with national standards	Design installations in accordance with BS 7671:2018+A3:2024 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. Design: • current capacity • voltage drop • earth fault paths • earth fault loop impedances • fault condition thermal constraints. [MC1, EC1, EC2, MC7, DC2]
S2.5 Inspect the suitability of resources for use, including tools, materials and equipment	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. [MC10]
S2.6 Analyse situations to identify potential causes of delays and errors	Delays and errors may include the worksite 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. [EC5]
S2.7 Mark out the position of electrical equipment	Positioning and securing component locations in line with specification requirements and current industry standards/working methods. When positioning, consideration should be given to 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. [MC1, EC1]
S2.8 Use tools, equipment and materials to carry out tasks	Setting up and using the correct hand and power tools, plant and equipment required to complete work activities, taking into consideration safe use of the equipment and suitability of tools and equipment, including suitable personal protective equipment (PPE), matched to specific tasks.

S2.9 Install cable containment systems	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 given to 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. [EC5]
S2.10 Install cabling	Install cables within containment systems or on support systems using appropriate methods for drawing in, laying and securing. Suitable consideration must be given to protection of cables during installation.
S2.11 Connect electrical equipment to installed wiring systems	Connecting/fixing electrotechnical system components together using appropriate methods of fixing as listed in the design specification/manufacturer's details with consideration of material type,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.
S2.12 Terminate cables and connect conductors	Terminate and secure the connection of conductors in line with specification requirements and current industry standards/working methods. When securing terminations/connections consideration should be given to external influences, building regulations, manufacturer's instructions and British Standards. Appropriate terminations/connections must be used to ensure security of connection/termination types and checks should be made to ensure termination/connections are level and secure.

S2.13 Measure and evaluate circuit conditions for differing load profiles	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 minimise impact of reactance on circuit conditions: • inductive • resistive • capacitive • reactive • power factor • power factor correction.
S2.14 Select suitable lighting lamps and luminaires for environment and usage	Select suitable types of lighting lamp and luminaire for given conditions, intended use and location. Consider factors affecting selection. Environment and usage: • space-height ratio • energy efficiency • statutory levels of illuminance • glare • utilisation factors • photometric data • conditions of evacuation • external influences • colour rendering.

Outcome 3 Commission electrotechnical systems (S3.1 – S3.5)	
Performance criteria	**Range and amplification**
S3.1 Prepare for inspection, testing and commissioning	Gather the information necessary for detailed inspection, testing and commissioning of electrical installations, including manufacturer's data, design information, tolerances, drawings and charts. [MC1, MC4]
S3.2 Inspect electrotechnical systems	Complete visual inspections as per relevant electrical inspection schedules used in accordance with BS 7671:2018+A3:2024 and IET Guidance Note 3.
S3.3 Test electrotechnical systems	Tests to be carried out on an electrical installation in accordance with BS 7671:2018+A3:2024 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. [DC1]
S3.4 Analyse and interpret information and data	Interpret 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. [MC6, MC7, DC1, DC4, DC5]
S3.5 Complete commissioning documentation	Complete all relevant sections/information that must be contained on initial verification documentation. Follow certification processes for a completed installation, with consideration given to responsibilities of relevant personnel in completion of the certification process. Learners must follow requirements for the recording and retention of completed initial verification documentation in accordance with BS 7671:2018+A3:2024. Ensure O&M manuals are complete and reflect the 'as fitted' work undertaken. Handover information to stakeholders. Documentation: • Electrical Installation Certificate • Minor Electrical Installation Works Certificate • schedule of inspections • schedule of test results. [EC1, EC3, EC4, EC5]

Outcome 4 Maintain electrotechnical systems (S4.1 – S4.10)	
Performance criteria	**Range and amplification**
S4.1 Communicate health and safety risks to stakeholders orally	Communicate with stakeholders in line with system maintenance undertaken including explaining unsafe situations and associated risks. Communications may relate to the production of a risk assessment for maintenance activities. Explain relevant content of the risk assessment to stakeholders. [EC1, EC2]
S4.2 Sequence activities required to complete task, including planning to isolate electrical supplies and informing relevant people	Follow correct sequence of activities to complete a maintenance task: • select tools/equipment • obtain method statement/work order • carry out safe and secure isolation (including getting permission to isolate) • carry out maintenance activities • remove isolation • functional testing.
S4.3 Allocate time and resources to complete the task including materials required	Application of appropriate timings for each stage of maintenance tasks: • select tools/equipment • obtain method statement/work order/permits • carry out safe and secure isolation (including getting permission to isolate) • carry out maintenance activities • remove isolation • functional testing. Liaise with stakeholders to agree timings to minimise disruption and enhance safety. [MC10]
S4.4 Collect and record electrical installation data	Collect relevant electrical installation data. Electrical installation data may include work records or equipment maintenance sheets. Familiarity with records of work, including: • preventative maintenance • reactive maintenance requirements. Inspection and test schedules may be company or system specific, so awareness needed of documentation to be completed for maintenance activities. [DC1, DC4, EC1, EC2, MC1, MC4, MC7]

S4.5 Analyse data from work activity	Interpret figures and values obtained from electrical installations (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. [MC6, DC1, DC4]
S4.6 Provide technical advice and guidance to technical and non-technical stakeholders	Convey 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. [EC1, EC2]
S4.7 Test electrical installation to ensure it is safe to work on	Check to ensure safe isolation has been carried out correctly and that any stored charge within the equipment has been discharged.
S4.8 Analyse information to identify potential faults	Inspect 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. Collate all available information and analyse regarding any possible or potential faults. Reference may also be made to manufacturer's instructions or specifications (fault-finding flow chart). [MC6, DC1, DC4]
S4.9 Think creatively to propose solutions for installation faults	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 for a number of reasons. Contingency budget planning needs to be reviewed regularly with consideration given to performance levels of existing equipment and plant. [MC2]

S4.10 Replace components of electrotechnical systems	Replace components within an electrical installation as necessary to meet industry and task specific requirements. Components: • lamps • tubes • accessories • wiring • containment • devices. Consideration should be given to safe/appropriate disposal of replaced components and ensuring all work has been recorded in work and O&M manuals.

Outcome 5 Decommission electrotechnical systems (S5.1 – S5.3)	
Performance criteria	**Range and amplification**
S5.1 Communicate with relevant stakeholders to ensure required information is available to undertake the task using electronic communication	Systems used in the tracking and monitoring of site/contract progress. This includes software packages (word processing, email, spreadsheets). [EC1, EC2]
S5.2 Make systems safe to work on including safe and secure isolation and discharging stored charge	Carry out safe isolation procedures and ensure that the electrical installations are discharged before commencing work on decommissioning. [MC7]
S5.3 Remove electrotechnical systems	Remove all redundant equipment and wiring of the electrical installation with consideration given to categorising waste produced during the decommissioning process. Using construction materials to make good the building fabric following component or system removal. Update and change records to reflect work undertaken.

Core content

All aspects of the common core and Building Services Engineering (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 principles, heat principles, light principles, acoustic principles
- 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 in other industries and contexts, and adapting it for use in construction and the built environment
- Health and safety – BSE regulations, safe working practices for the safe isolation of systems
- 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 Information Technology (IT) resources.

Guidance for delivery

Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery.

Formative assessment – oral Question & Answer (Q&A), observation of measuring activities:

- Practical – use of pre-set formative assessment to carry out tasks and record on standardised form.
- Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use a 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 United Kingdom (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)
  ISBN-13: 978-1510432246
- 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)
  ISBN-13: 978-1510432253
- 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)
  ISBN-13: 978-1785611704
- Electronics For Service Engineers Author: J Cieszynski / D Fox Publisher: Routledge (2011)
  ISBN-13: *0750634766*

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/

Scheme of Assessment – Electrotechnical engineering

The electrotechnical engineering occupational specialism is assessed by one practical assignment. The duration of the assessment is 24 hours.

Learners will be assessed against the following assessment themes:

- Health and safety
- Design and planning
- Systems and components
- Inspect and test systems and components
- Report and information
- Handover and communication
- Working with faults.

By completing the following tasks:

Task	Typical knowledge and skills
Task 1 – Plan the installation	• Displays a breadth of knowledge and practical skills that enables them to design and plan for the installation of an electrical system. • Candidates will need to produce documents to industry standards that clearly states how they will carry out the installation.
Task 2 – Install, commission and decommission	• Complete the given installation, commissioning and decommissioning task successfully. • The task is carried out in a clear and logical sequence. • Works in a safe manner, able to carry out testing and interpret and record test results accurately. • Tools, materials and equipment are selected and used correctly. • Consideration to environmental sustainability and recycling of materials. Techniques used to make building fabric repairs to restore work area to pre-installation condition. • All work carried out in line with relevant manufacturer's instructions/building regulations.
Task 3 – Carry out maintenance activity	• Applies knowledge and practical skills in locating and rectifying faults in a component or system. • Candidates will need to be able carry out, record and communicate maintenance activity with a customer.

The information provided in the following tables demonstrates to approved providers the weightings of each performance outcome and how each performance outcome is assessed.

Performance outcome and weighting (%)	**High level tasks** *Provide specific instructions for candidates to provide evidence for and are the same for every version of the assessment*	**Assessment Theme**	**Typical evidence**
PO2 Install electrotechnical systems (36%)	T1 Planning the installation T2 Installation, commissioning and decommissioning	Health and Safety Design and Planning Systems and components Reports and information	Assessment of risk, PPE, working safely Design grids, design forms, assessment of characteristics, materials take off sheet Using tools and equipment, installation of wiring components Interpretation of drawings, specifications, manufacturer instructions
PO3 Commission electrotechnical systems (30%)	T1 Planning the installation T2 Installation, commissioning and decommissioning T3 Carrying out maintenance	Health and Safety Systems and components Reports and information Inspection and testing Handover and communication	Assessment of risk, PPE, working safely Using tools and using tools and equipment, installation of wiring components Documentation completion Inspection and testing checks Handover to customer, reflective accounts

PO3 Maintain electrotechnical systems (20%)	T2 Installation, commissioning and decommissioning T3 Carrying out maintenance	Health and safety Systems and components Reports and information Handover and communication Working with faults	Assessment of risk, PPE, working safely Repair/replacement of components, use of tools Documentation completion Communication with customer to diagnose fault Fault diagnosis, fault rectification
PO4 Decommission electrotechnical systems (14%)	T2 Installation, commissioning and decommissioning T3 Carrying out maintenance	Health and Safety Systems and components	Safe isolation procedures Handling / disposing of components and materials

Protection systems engineering

Level	3
GLH	570
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 while 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 protection systems engineering • Electrical and electronic principles applicable to electronic protection systems • Electronic protection systems and their purpose • Information and data used in the protection systems industry • Protection systems installation and commissioning • Protection systems maintenance and decommissioning. Note: Completion of the core and this occupational specialism provide threshold competence for entry into industry but does not provide full proof of occupational competence.
Learner preparation	Learners may be introduced to this specialism by asking themselves questions such as: • What does a protection systems engineer do? • What skills are required in the role of a protection systems engineer? • What steps are required to become a qualified protections systems engineer? • What data and details are needed when planning protection system installations? • What types of checks and adjustments may be required to protection systems during and after installation?
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: 1. Install protection systems 2. Commission protection systems 3. Maintain protection systems 4. Decommission protection systems
Maths, English and Digital skills	Completion of this specialism will give learners the opportunity to develop their Maths, English and digital skills. Where applicable, this information is included under the knowledge outcome, shown in square brackets.

Link to prior learning (Common Core)	Learners will build on their core knowledge and understanding by focusing on specialised knowledge required to work in and around protection systems. Underpinning knowledge and understanding have been referenced in relation to the relevant knowledge outcomes.
Assessment method	Practical assignment.

Outcome 1: Protection systems knowledge criteria
Learners will gain knowledge and understanding of the following content areas: Health and Safety (K1.1) Science (K1.2) Tools, equipment and materials (K1.3 – K1.4) Protection systems (K1.5 – K1.7) System installation (K1.8 – K1.11) System commissioning (K1.12 – K1.14) System maintenance (K1.15 – K1.18) Decommissioning (K1.19 – K1.20)

Health and Safety (K1.1)	
Knowledge criteria	**Range and amplification**
K1.1 Safe working practices specific to work on protection systems	Safe working practices: • carrying out safe isolation before working on 230 V AC connections to systems and equipment • selection of appropriate tools for isolation in accordance with Health and Safety Executive (HSE) GS38 • discharge / disconnection of stand-by supplies • requirements for working with and disposing of chemical batteries and detection devices • requirements for working with fibre optic cables. Safe working practices with reference to full, current industry recognised electrical safe isolation and lock-off procedures. Hazards and personal protective equipment (PPE) associated with working with chemical and radioactive equipment and fibre-optic cables. [EC5]
	Underpinning Core Knowledge: C1.5, C1.12, C1.7, C12.6, C5.7, C5.8

Science (K1.2)	
Knowledge criteria	**Range and amplification**

K1.2 Electrical/electronic science principles	• Electrical principles – relationship between voltage, current, resistance, and power in electrical circuits.
	• Resistive circuits – effects of series and parallel resistance in DC electrical circuits.
	• Circuit measurement – using a digital multimeter.
	• Capacitance – properties, construction and function of capacitors.
	• Inductance – properties, construction and function of inductors.
	• Transformers – properties, construction and function of transformers.
	• Semiconductors – properties, construction and function of semiconductor devices.
	
	The properties of, and the relationship between, electromotive force (EMF), electric current and resistance. Reference to Ohm's law, potential difference (PD) and the effects of voltage drop in DC circuits. Recognise SI symbols used to denote electrical properties.
	
	The material properties of conductors and insulators.
	Power in DC electrical circuits.
	
	Resolve simple problems using equations that relate voltage, current, resistance and power.
	
	Recognise circuit symbols used to denote resistors.
	The effects on an electrical circuit of series, parallel and series/parallel connected resistances.
	Resolve resistance circuit problems by calculation.
	
	Use of a multimeter to measure voltage, current and resistance in low-voltage DC electrical circuits:
	• continuity testing
	• testing components:
	    ○ resistors
	    ○ capacitors
	    ○ inductors
	    ○ diodes
	    ○ light emitting diodes (LEDs).
	
	Capacitance:
	• construction and basic operation of capacitors
	• factors affecting capacitance
	• units of capacitance
	• identify types and polarity of capacitors
	• safety considerations when handling capacitors
	• typical applications
	• calculations to determine:
	    ○ value of capacitors

	- resolve series capacitor circuits
	- resolve parallel capacitor circuits.
	
	Inductance:
	- construction and basic operation of inductors
	- factors affecting the value of an inductor
	- units of magnetic flux, flux density and inductance
	- reasons for, and effects of, back EMF in inductors
	- methods of suppressing the back EMF
	- typical applications
	- methods of determining the field polarity around an inductor
	- self-inductance and mutual inductance
	- calculations to determine:
	  - flux density
	  - induced EMF
	  - self-induced EMF
	  - mutual induced EMF.
	
	Transformers:
	- construction and basic operation of transformers
	- typical applications
	- calculations to determine the effects of transformer turns ratio on voltage and current.
	
	Semiconductors:
	- semiconductor devices:
	  - silicon diode
	  - LED
	  - NPN bipolar transistor
	- basic construction, operation and function of the listed semiconductor devices
	- recognise common devices and the means of identifying polarity
	- typical applications.
	
	[MC5, MC6]

	Underpinning Core Knowledge: C2.1, C2.2, C2.5, C12.5

Tools, equipment and materials (K1.3 – K1.4)	
Knowledge criteria	**Range and amplification**
K1.3 Tools and equipment used when working with protection systems	Hand tools: • rules • levels • laser levels • plumb lines • cable cutters • wire cutters • pliers • screwdrivers • wire strippers • knives • files • wrenches • hammers • saws • hand crimping tools • insulation displacement tools. Power tools: • slotted drive system (SDS)/hammer drills • combi drills • electric screwdrivers. Equipment: • digital multimeter • radio frequency (RF) signal strength meter • network cable tester • insulation resistance tester • smoke hoods • smoke cannisters • testing/commissioning equipment • programming devices • programming software. 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. Safety checks to include: • checking equipment is safe to use • appropriate instrument leads selected for the test • correct speed setting • correct attachments • attached correctly • guards in place • use of correct PPE.

	Underpinning Core Knowledge: **C1.11, C7.4, C14.1**
K1.4 Operation and handling requirements of tools and commissioning equipment	• User checks • calibration checks • operation/function of equipment.
	Underpinning Core Knowledge: C14.1

Protection systems (K1.5 – K1.7)	
Knowledge criteria	**Range and amplification**
K1.5 Types of protection systems, signalling and notification	Protection systems: • fire detection systems (conventional, addressable) • access control systems • video surveillance (closed-circuit television (CCTV)) • intruder and hold up alarm systems (I&HAS) • addressable emergency lighting systems. Signalling and notification – Specifications and devices used for signalling and notification in protection systems. Reference to guidance on different types of protection systems used in different building environments. This will range from conventional basic systems to intelligent digital addressable systems at different voltage levels. Reference must be made to relevant British Standards and manufacturer's literature. The relationship of fire detection and security systems to the fire and security industry, and the requirements and implementation of security risk assessments. Devices employed for local audible and visual signalling in protection systems. Standards and requirements for each of these devices. Methods and equipment required for remote signalling to an alarm receiving centre (ARC). Standards and requirements for each of these devices. Methods, and equipment required, for private signalling (speech dialler, mobile applications).

K1.6 Protection system components	Components:
	• control equipment
	• indicating equipment
	• detection devices
	• sensing devices
	• manually operated devices
	• warning and signalling devices
	• cameras
	• recording equipment
	• monitoring equipment
	• door locking devices
	• door release devices
	• door lock override devices
	• power supply back-up devices/components.
	
	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.
	
	Consideration of system grade for I&HAS.
	Method of determining system grade, and effect on selection of components and equipment.
	
	Consideration of coverage patterns for detectors and cameras.
	
	Standby batteries:
	• regulations relating to standby batteries relevant to the system type and grade
	• use of uninterruptible power supply (UPS) for standby applications for equipment such as:
	  ◦ network video recorders (NVRs)
	  ◦ administration PCs
	  ◦ servers.
	[DC1, DC5, DC6]

<table>
<tr>
<td rowspan="2">K1.7 Protection system circuits</td>
<td>Circuits:
• open loop
• closed loop
• fully supervised loop (FSL)
• addressable
• radial
• audio/visual circuit
• communication data buses (i.e. RS 485, RS 422, RS 232, USB)
• wireless
• AC and DC supplies.

Circuit properties for a given protection system including suitability, applications, advantages and limitations.

Data bus topologies and connection.

Effects of series and parallel resistances and configurations.

Effects of voltage drop.
[MC7]</td>
</tr>
<tr>
<td>Underpinning Core Knowledge:
C2.5</td>
</tr>
</table>

System installation (K1.8 – K1.11)	
Knowledge criteria	**Range and amplification**
K1.8 Methods of selecting and installing cable installation and wiring support systems	Cable installation and wiring support systems: • single and multi-core thermoplastic cable • FP200 – fire resistant cable • data cable CAT5e/6e • coaxial • cable tray • cable conduit (steel and polyvinyl chloride (PVC)) • cable trunking (steel and PVC) • ladder racking • cable basket. How to install cables and containment in line with current legislation and industry practices. Need for segregation of particular cable systems. Selection of cable suitable for: • current capacity • voltage drop limitations • signal transmission type • environment. Selection of wiring support system suitable for: • environment • type of cables • quantity of cables • availability of fixing methods. When installing cables consideration should be given to current Building Regulations, manufacturer's instructions and British Standards. [EC4]
	Underpinning Core Knowledge: C1.1, C2.3, C2.6, C7.2, C12.4, C12.7

<table>
<tr><td rowspan="2">K1.9 Termination of cables</td><td>Cables:
• single and multi-core thermoplastic cable
• FP200 – fire resistant cable
• CAT5e/6e data cable
• unshielded twisted pair (UTP) and shielded twisted pair (STP) data cables
• coaxial
• shielded data cable.

Termination and securing of cables, with the use of glands where appropriate, as 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.</td></tr>
<tr><td>Underpinning Core Knowledge:
C1.3, C7.2, C7.3, C7.4</td></tr>
<tr><td rowspan="2">K1.10 Methods of terminating and connecting conductors</td><td>Terminating and connecting:
• screwed
• crimped
• compression
• insulation displacement
• clamp.

Termination and connection of conductors as detailed in the range in line with specification requirements and current industry standards/working methods.

To include consideration of:
• advantages and limitations of termination and connection methods
• consequences of poor connections
• shape and type of material being connected
• junction of materials
• volume/number of conductors.

When securing terminations/connections consideration should be given to current Building Regulations, manufacturer’s instructions and British Standards.</td></tr>
<tr><td>Underpinning Core Knowledge:
C1.3, C2.3, C7.2, C7.3, C7.4</td></tr>
<tr><td rowspan="2">K1.11 Methods of supporting protective system components</td><td>Selection of appropriate fixing methods, considering:
• load bearing
• environment
• building structure/materials
• aesthetics.</td></tr>
<tr><td>Underpinning Core Knowledge:
C7.5</td></tr>
</table>

System commissioning (K1.12 – K1.14)	
Knowledge criteria	**Range and amplification**
K1.12 Inspections of protection systems	Standard procedures and processes for completing visual inspections of electronic protection systems in line with current standards and codes of practice. Consideration should also be given to operation and maintenance (O&M) manuals.
	Underpinning Core Knowledge: C1.3, C1.6, C13.4
K1.13 Testing of protection systems	Tests to be carried out on electronic protection systems in line with relevant current standards and codes of practice, and manufacturer's documentation. Functional tests and commissioning to manufacturer's specifications and system requirements. Identification of expected and incorrect test values, and potential implications of incorrect test values. [DC1, DC4]
	Underpinning Core Knowledge: C1.3
K1.14 Verification of protection systems	Verifying compliance with system design and manufacturer's specifications, and relevant current standards and codes of practice. Completion of documentation relevant to the protection system, and importance of documentation/O&M manual handover to end user.
	Underpinning Core Knowledge: C1.3, C13.4

System maintenance (K1.15 – K1.18)	
Knowledge criteria	**Range and amplification**
K1.15 Types of protection system maintenance	System maintenance: • planned and preventative maintenance (PPM) • reactive maintenance. Legal requirements relating to PPM and responsibilities for undertaking maintenance regimes. Advantages and limitations of PPM and reactive maintenance. Requirements for completing documentation and updating O&M manuals. The tests that must be carried out during a maintenance activity for each of the listed protection systems.
	Underpinning Core Knowledge: C13.1, C13.2, C13.3, C13.4
K1.16 Fault-finding and rectification techniques	Fault-finding techniques: • identification of symptoms • collection and analysis of data • use of sources/types of information (circuit schedule, installation specifications, drawings/diagrams) • determining nature/characteristics of faults through discussion and questioning • checking and testing • analysis of results/information. Rectification techniques: • adjust • repair • replace. Safe working procedures following evaluation and the application of appropriate and logical fault diagnosis methods and techniques. Diagnosis of electrical, electronic and software related faults using engineering decisions and evaluation of symptoms and findings. Appropriate and efficient action(s) that should be recommended to rectify faults. [MC2]
	Underpinning Core Knowledge: C8.1, C13.5

K1.17 Maintenance requirements for different building types and locations	Building types: • private • commercial • house in multiple occupation (HMO) • residential. 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 (hospitals, chemical plants, paint stores). [EC5]
	Underpinning Core Knowledge: C7.2, C7.3
K1.18 Maintenance of older systems and installations	Identification of older systems that may not be compliant with current regulations and reporting on condition and suitability for continued use.
	Underpinning Core Knowledge: C12.7

Decommissioning (K1.19 – K1.20)	
Knowledge criteria	**Range and amplification**
K1.19 Making systems safe to decommission	Isolation of systems from the supply source and outgoing integrated services, for example, 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.
	Underpinning Core Knowledge: C1.7, C5.3, C5.7, C7.5

K1.20 Methods of identifying potential issues before decommissioning systems	Methods, including reviewing O&M manuals, and consultation of component data sheets and drawings. Benefits of devising a timely plan when decommissioning systems. [MC2, EC5]
	Underpinning Core Knowledge: C4.11, C8.2, C8.4, C13.4

Outcome 2: Install protection systems (S2.1 – S2.12)	
Performance criteria	**Range and amplification**
S2.1 Assess risk associated with tasks	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 the protection system being installed. Consideration should be given to recording of risk assessment findings in line with regulations as well as responsibilities of employees versus employers. [EC4, EC5]

S2.2 Collect and collate information required to complete tasks	Information: • manufacturer's instructions • data sheets • building regulations • drawings • BS/BS EN standards • relevant codes of practice • inspectorate standards. 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 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. [EC4, EC5]
S2.3 Select tools, equipment and materials to complete tasks	Select 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.
S2.4 Inspect the suitability of plant for use, including tools, materials and equipment	Inspect and use 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 and non-statutory regulations and codes of practice.
S2.5 Analyse formal and informal information to identify potential causes of delays and errors	Delays and errors may include the work site not being ready, having incorrect drawings, insufficient materials, resources. Learners should review available progress plans such as Gantt charts/critical path analysis tracking, as well as site meeting notes to discuss progress, detailing any causes for concerns. [MC2, MC6, MC7, EC4, EC5]
S2.6 Think creatively to adapt designs appropriately to minimise delays and errors	Engineering solutions to suit different environments and un-planned situations, after consultations with site managers and designers, for example where site conditions are different from 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.

S2.7 Mark out the position of equipment	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 given to plans/drawings, Building Regulations, manufacturer's instructions and British Standards. Consideration 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. [MC1, EC5]
S2.8 Use tools, equipment and materials to carry out tasks	Tasks: • installing wiring and containment systems • connecting equipment. 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 safe use of the equipment and suitability of tools and equipment, including suitable PPE, matched to specific tasks.
S2.9 Install cable containment systems	Engineering cable and containment installations – to include the measuring and cutting of materials (conduit, trunking, basket and tray) to required length as detailed in the job specification. Materials should be cut using appropriate cutting equipment with consideration given to safety, materials and equipment available. Consideration should also be given to 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, and material data sheets reviewed, where information given must be followed to ensure the safety of the user and correct installation of components. [MC1]
S2.10 Install cabling	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. Suitable means used to identify cables.

S2.11 Connect equipment to the installed wiring systems	Connecting/fixing protection system components (call points, detectors, control equipment) together using appropriate methods of fixing as listed in the design specification/manufacturer's details with consideration given to material type, materials, equipment and 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. [MC1]
S2.12 Terminate and connect cables and conductors	Terminate and secure cable glands (armoured, insulated, coax and data cables) and conductors in line with specification requirements and current industry standards/working methods. When securing terminations consideration should be given to 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, with no exposed conductors.

Outcome 3: Commission protection systems (S3.1 – S3.8)	
Performance criteria	**Range and amplification**
S3.1 Prepare for inspection, testing and commissioning	Gathering the information necessary for detailed inspection, testing and commissioning of protection systems including: • manufacturers' data • design information • tolerances • drawings • charts. [EC4, EC5]
S3.2 Inspect protection systems	Standard procedures and processes for how to complete visual inspections of electronic protection systems as per relevant current standards and codes of practice. Consideration should also be given to O&M manuals.

S3.3 Test protection systems	Tests to be carried out on electronic protection systems in accordance with relevant current standards and codes of practice, and manufacturer's documentation. Tests to be carried out on protection systems as per relevant current standards and codes of practice. Learners must select the appropriate instrument for each test to be carried out in terms of: • ensuring the instrument is fit for purpose • verifying calibration • identifying the correct scale or setting. [MC1, MC2, MC4]
S3.4 Analyse and interpret information and data from ICT applications	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. [MC6, DC1, DC4, DC5]
S3.5 Adjust protection systems equipment as required by installation standards	Considering relevant adjustments required in relation to system requirements (adjusting settings of sensors, detectors, cameras) with reference to manufacturer's information and design specification for adjustment parameters. Making adjustments with consideration of industry standards and requirements. [DC4, EC5]
S3.6 Complete documentation relevant for tasks	Documentation: • system test record • Certificate of Conformance • as fitted document • handover acceptance. Completing all relevant sections/information that must be included in initial verification documentation. Following certification processes for a completed installation, with consideration given to responsibilities of relevant personnel in relation to the completion of the certification process. Learners must follow requirements for the recording and retention of completed commissioning documentation in accordance with relevant standards and codes of practice. [EC1, EC2, EC3, EC4, DC2]

S3.7 Use oral and non-verbal communication skills to demonstrate system operation	Making reference to O&M manuals as well as manufacturer's information when conveying information on the operation of systems to client and users. Information handed over to client and/or users. Use of techniques to ensure understanding, including user demonstration and explanation. **[EC1, EC2, EC3, EC6, DC3, DC5]**
S3.8 Update digital building information management system software and/or O&M manuals	Updating relevant system software may include using different types of programs: • word processing • email • spreadsheets • computer aided design (CAD) • programmable logic controllers (PLCs) • building management system (BMS) software. Information relating to both basic and advanced systems. Ensuring operational and maintenance manuals are complete and reflect the 'as fitted' work undertaken. [DC1, DC2, DC3, DC5, DC6]

Outcome 4: Maintain protection systems (S4.1 – S4.10)	
Performance criteria	**Range and amplification**
S4.1 Communicate health and safety risks to stakeholders orally	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. [EC1, EC2, EC6]

S4.2 Sequence activities required to complete task including planning to isolate electrical supplies and informing relevant people where required	Follow correct sequence of activities to complete a maintenance task:
	• obtain method statement/work order
	• select tools/equipment
	• carry out safe and secure isolation (including getting permission to isolate)
	• identify checks to be made before working on equipment with the 230 V AC supply connected. Checks to include:
	    • correct location of all barriers
	    • no damage to barriers or insulation
	    • no modifications to the equipment electrical supply which have not been approved by the equipment manufacturer
	• carry out maintenance activities
	• remove isolation
	• functional testing.
	[MC10]

S4.3 Allocate time and resources to complete the task including materials required	Review sequence of maintenance activities as detailed in S4.2. With application of appropriate timings for each stage. Liaison with stakeholders to agree timings to minimise disruption and enhance safety. [MC1, MC2]
S4.4 Collect system data from ICT applications	ICT, including use of computers, digital transmission over internet protocol (IP), email and mobile communication technology for the collection of data and completion of work sheets/maintenance sheets. [MC6, DC4, EC3]
S4.5 Record system data	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. [EC1, EC3]
S4.6 Test equipment to ensure it is safe to work on	Check to ensure safe isolation has been carried out correctly and that any stored charge within the equipment has been discharged. Identify checks to be made before working on equipment with the 230 V AC supply connected. Checks to include: • correct location of all barriers • no damage to barriers or insulation • no modifications to the equipment electrical supply which have not been approved by the equipment manufacturer. [DC1]
S4.7 Inspect, test and analyse information to identify potential faults	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 (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. [MC1, MC2, MC6, DC4]

S4.8 Think creatively to propose solutions for installation faults	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. 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. [MC6, DC4, MC9]
S4.9 Communicate written technical advice and guidance to technical and non-technical stakeholders	Communicate with stakeholders and obtain necessary permissions to: • rectify faults • prevent potential faults • improve systems for changing conditions. Convey information (safety considerations, system maintenance requirements) to inform and educate stakeholders with a specific focus on ensuring all stakeholders are aware of health and safety responsibilities. Be able to overcome potential barriers to successful communication with specific reference to language and methods used for both technical and non-technical stakeholders. [EC1, EC3, EC6, DC3, DC5]
S4.10 Replace components of protection systems	Components: • sensors • detectors • control equipment • signalling equipment • monitoring equipment • power supplies. Replace components within a protection system as necessary to meet industry and task-specific requirements. Consideration should be given to: • safe/appropriate disposal of replaced components • ensuring correct adjustment (where required) of replacement components to maintain system specification • ensuring replacement component grade (where applicable) is equal to or better than the original • ensuring all work has been recorded or records of work updated including O&M manuals.

Outcome 5: Decommission protection systems (S5.1 – S5.3)	
Performance criteria	**Range and amplification**
S5.1 Communicate with stakeholders to ensure required information is available to undertake tasks using electronic communication	Information on systems used in the tracking and monitoring site/contract progress. Communications may include use of software packages (word processing, email, spreadsheets). Information sources may include CAD, PLCs, BMS software, and also information relating to both simple and complex systems. [EC1, EC4, EC6, MC7, DC3, DC5]
S5.2 Make systems safe to work on including safe isolation and discharging stored charge	Carry out safe isolation procedures and ensure that any charged storage devices such as power supplies are dead before commencing work on decommissioning.
S5.3 Remove protection systems and maintain records	Remove all redundant equipment and wiring of the protection system with consideration given to categorising waste produced during the decommissioning process. Use construction materials to make good the building fabric following component or system removal. Update and change records to reflect work undertaken.

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 Principles, Heat Principles, Light Principles, Acoustic Principles
- 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.

Guidance for delivery

Where content is common across installation, commissioning and maintenance activities, it is recommended 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.

Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes.

Suitable formative assessment methods include:

- oral Q&A
- 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 activities to confirm skills and understanding.

Learners can use variety of methods to carry out activities, calculators, apps, office IT.

Learning can be reinforced by:

- revisiting learning
- group discussions
- peer support system.

Centres should ensure content is delivered in line with current, up-to-date, industry practice. Teaching coverage must represent the type of equipment currently available and accepted for use in the UK industry. Current and emerging testing and programming methods should be included in the delivery where possible.

Delivery staff should remain up to date with the industry sector, using opportunities for CPD to enhance and upgrade their technical knowledge. This could be achieved by attending industry conferences and Professional Body/Trade Association events or accessing trade journals.

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) – Peter Tanner (Hodder Education, 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) – Peter Tanner (Hodder Education, 2019)
- Requirements for Electrical Installations, IET Wiring Regulations, Eighteenth Edition, BS 7671:2018 (Amendment 2:2022) – The Institution of Engineering and Technology (IET, 2022)
- Closed Circuit Television – Joe Cieszynski (Newnes, 3rd edition 2006)
- Intruder Alarms – Gerard Honey (Newnes, 3rd edition 2007)
- Electrician's Guide to Fire Detection and Alarm Systems – The Institution of Engineering and Technology (IET, 2021)

Websites

- Institute for Apprenticeships and Technical Education https://www.instituteforapprenticeships.org/
- National Careers Service https://nationalcareers.service.gov.uk/job-profiles/security-systems-installer
- Security Systems and Alarms Inspection Board (SSAIB)- https://www.ssaib.org
- National Security Inspectorate (NSI) - https://www.nsi.org.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

Scheme of Assessment – Protection systems engineering

The protection systems engineering occupational specialism is assessed by one practical assignment. The duration of the assessment is 15 hours. Learners will be assessed against the following assessment themes:

- Health and safety
- Design and planning
- Systems and components
- Inspect and test systems and components
- Report and information
- Handover and communication
- Working with faults.

By completing the following tasks:

Task	Typical Knowledge and Skills
Task 1 - Plan the installation	• Displays a breadth of knowledge and practical skills that enables them to carry out and plan for the installation of an electronic security or emergency system. • Candidates will need to produce documents to industry standards that clearly state how they will carry out the installation.
Task 2 – Install and commission Task 4 - Decommission	• Complete the given installation, commissioning and decommissioning tasks successfully. • The tasks are carried out in a clear and logical sequence. • Works in a safe manner, able to carry out testing and interpret and record test results accurately. • Tools, materials and equipment are selected and used correctly. • Consideration to environmental sustainability and recycling of materials. • Techniques used to make building fabric repairs to restore work area to pre-installation condition. • All work carried out in line with relevant standards, codes of practice, and manufacturer's instructions.
Task 3 – Carry out maintenance activity	• Applies knowledge and practical skills in locating and rectifying faults in a component or system. • Candidates will need to be able carry out, record and communicate maintenance activity with a customer.

The information provided in the following table demonstrates to approved providers the weightings of each performance outcome and how each performance outcome is assessed.

Performance outcome and weighting (%)	High level tasks *Provide specific instructions for candidates to provide evidence for and are the same for every version of the assessment*	Assessment Theme	Typical evidence
PO2 Install protection systems (29%)	T1 Planning the installation T2 Installation and commissioning	• Health and Safety • Design and planning • Systems and components • Reports and information	• Assessment of risk, PPE, working safely • Method statements, plans and drawings, material lists • Using tools and equipment, installation of wiring components • Interpretation of drawings, specifications, manufacturer instructions
PO3 Commission protection systems (28%)	T1 Planning the installation T2 Installation and commissioning T3 Carrying out maintenance	• Health and Safety • Systems and components • Reports and information • Inspection and testing • Handover and communication	• Assessment of risk, PPE, working safely • Using tools and Using tools and equipment, installation of wiring components • Documentation completion • Inspection and testing checks • Handover to customer

PO4 Maintain protection systems (31%)	T2 Installation and commissioning T3 Carrying out maintenance	• Health and safety • Systems and components • Reports and information • Handover and communication • Working with faults	• Assessment of risk, PPE, working safely • Repair/replace components, use of tools • Documentation completion • Communication with customer to diagnose fault • Fault diagnosis, fault rectification
PO5 Decommission protection systems (12%)	T3 Carrying out maintenance T4 Decommissioning	• Health and Safety • Systems and components	• Safe isolation procedures • Extracting components, handling / disposing of components and materials

Gas engineering

Level	3
GLH	650
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 while utilising a range of materials, methods and techniques. Learners will further develop their Core 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. Note: Completion of the core and this occupational specialism provide threshold competence for entry into industry but does not provide full proof of occupational competence.
Learner preparation	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 skills are required in the role of a gas engineer? • What steps are required to become a qualified gas engineer?
Underpinning knowledge outcome	On completion of this specialism, learners will understand: 1. Gas knowledge criteria
Performance outcomes	On completion of this specialism, learners will be able to: 1. Install gas systems 2. Commission gas systems 3. Maintain gas systems 4. Decommission gas systems
Maths, English and Digital skills	Completion of this specialism will give learners the opportunity to develop their Maths, English and digital skills. Where applicable, this information is included under the knowledge outcome, shown in square brackets.

Link to prior learning (Common Core)	Learners will build on their core knowledge and understanding by focusing on specialised knowledge required to work in and around gas systems. Underpinning knowledge and understanding have been referenced in relation to the relevant knowledge outcomes.
Assessment method	Practical assignment.

Outcome 1 - Gas knowledge criteria
Learners will gain knowledge and understanding of the following content areas: Health and Safety (K1.1 – K1.3) Tools, equipment and materials (K1.4 – K1.5) Gas systems (K1.6 – K1.15) Gas engineering science (K1.16) Pipework technology (K1.17 – K1.19) Legislation and industry guidance (K1.20) Building technology (K1.21) System installation (K1.22) System commissioning (K1.23– K1.26) System maintenance (K1.27 – K1.28) Decommissioning (K1.29 – K1.30)

Health and safety (K1.1 – K1.3)	
Knowledge criteria	**Range and amplification**
K1.1 Typical hazards and risks associated with working with gas systems	The typical hazards associated with working with gas systems and how to negate the risks: • asbestos • explosions • carbon monoxide poisoning • slips and trips • manual handling • working at height • burns • dust • electrocution.
	Underpinning Core Knowledge: C1.5, C1.14, C1.15
K1.2 Safe working practices associated with working with gas systems	Safe working practices associated with working with gas systems including: • building regulations • documents (risk assessments and method statements) • PPE. [EC3, EC5]
	Underpinning Core Knowledge: C1.4, C1.5, C1.7, C1.11, C1.15, C7.2

K1.3 Emergency procedures for unsafe situations	The unsafe situations that that may occur in the workplace: • gas escapes • explosions • carbon monoxide. The correct procedures and reference documents to use if they do arise: • The Gas Safety (Rights of Entry) Regulations 1996 • Gas Industry Unsafe Situations Procedure (IGEM/G/11 Edition 2 with amendments July 2022 and June 2024). When unsafe situations need to be reported with consideration given to the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 2013. [EC5]
	Underpinning Core Knowledge: C1.5, C1.7, C1.9, C1.10, C1.15

Tools, equipment and materials (K1.4 – K1.5)	
Knowledge criteria	**Range and amplification**
K1.4 Types of tools and equipment, and materials	Tools, equipment and materials, their correct method of use and when they should be used, for access and measuring when working on gas systems: • pressure gauges • combustion performance analyser • leak detector • pipe cutter • hacksaw • blowtorch • spanner • water pump pliers • bending machine • drill • hammer • screwdrivers • temporary continuity bonds • step ladders • mobile scaffolding. The characteristics and properties of different tools, equipment and materials and what makes them suitable for different tasks.
	Underpinning Core Knowledge: C14.1

K1.5 Operation and handling requirements of tools, equipment and materials	How tools, equipment and materials are maintained and stored to minimise damage and maximise longevity: • pressure gauges • combustion performance analyser • leak detector • temporary continuity bonds. The processes for maintaining and re-calibrating equipment, and the implications of not following these processes correctly.
	Underpinning Core Knowledge: C1.1, C1.8, C14.2

Gas systems (K1.6 – K1.15)	
Knowledge criteria	**Range and amplification**
K1.6 Types of components and their suitability for different appliances and types of systems	The requirements of different components and their suitability for different systems, including: • purpose • sequence of operations • appliance type. Reference to manufacturer's instructions. Components: • fan • air/gas ratio control valve • thermistors • printed circuit board • multi-functional control valve • air pressure switch • flame supervision devices. Appliances: • water heaters • central heating boilers • space heaters • cookers • gas meters (≤ 6 m^3/h) • heat pumps • hydrogen boilers. Systems: • natural gas (NG) • liquefied petroleum gas (LPG). [EC5]
	Underpinning Core Knowledge: C12.3, C12.8, C7.4

K1.7 How components operate within a system/appliance and integrate to enable the system to operate effectively	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. Components: • fan • air/gas ratio control valve • thermistors • printed circuit board • multi-functional control valve • air pressure switch • flame supervision devices. Appliance: • water heaters • central heating boilers • space heaters • cookers • gas meters (≤ 6 m /h).
	Underpinning Core Knowledge: C12.3, C12.8
K1.8 Factors that affect the choice and suitability of components included in a system	Characteristics of components in a system and how these affect choice and suitability. Factors: • location • gas type • appliance type • size • independent certification/approval (CE marking) • legislation • environmental/efficiency.
	Underpinning Core Knowledge: C12.3, C12.5, C12.8
K1.9 Waste and waste products	Waste produced within a gas appliance and how these inform servicing and maintenance schedules for the gas system/appliance. Waste and waste products including types of systems, attributes hazards to user, interaction with other parties, environmental impact: • magnetite • corrosion smells • bacteria.
	Underpinning Core Knowledge: C1.13, C5.3, C5.7, C5.8

K1.10 Safety devices applicable to gas systems, their characteristics and operation	Safety devices used in gas systems/appliances, their testing procedures and how to replace if faulty to ensure safe use of the appliance/system, such as: • 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 • thermostats • flame supervision devices. [MC2]
K1.11 Gas and the combustion process	The combustion process and analysis including complete and incomplete combustion, the by-products (carbon dioxide (CO_2) levels, carbon monoxide (CO) levels oxygen (O_2) levels) of combustion and their trigger values. Types of burners (simplex and duplex) and interaction with other devices. These include ventilators and mechanical heat ventilation recovery (MHVR). Gas properties: • correct gas type for appliance being installed • calorific values • heat input/output • flame speed • ignition temperature • flammability limit • freezing temperatures • relative density • Wobbe numbers.
K1.12 Mechanical heat ventilation recovery (MHVR)	MHVR system. The method of extracting useable heat from the ambient air to further reduce heating costs - flue gas recycling. The combustion process, correct operation, safe operation and suitability for different types of system.
K1.13 Types of chimneys and chimney systems in relation to gas appliance types	The fundamental operating principles of the various chimneys and chimney systems, their testing requirements and their suitability for different appliance types: • open flued (type B appliances) • room sealed (type C appliances) • flueless (type A appliances).

K1.14 Types of ventilation in relation to gas	The types of ventilation and their requirements for each fuel, flue type and appliance: • permanently open • closeable • flyscreen • terracotta • unsleeved • incomplete • cooling air • high/low level ventilation • compartment ventilation • ventilation through two or more rooms • mechanical ventilation. Type A appliance (flueless) ventilation requirements and calculations. Type B appliance (open flued) ventilation requirements and calculations. Type C appliance (room sealed) ventilation requirements and calculations. [MC2]
K1.15 Types of gas appliances and their system requirements	Types of gas appliances and their system requirement: • water heaters • central heating boilers • space heaters • cookers • gas meters (≤ 6 m^3/h).

Gas engineering science (K1.16)	
Knowledge criteria	**Range and amplification**
K1.16 Scientific principles and concepts as applied to gas engineering	Scientific principles of combustion and the effects these can have on the combustion process: • complete combustion • incomplete combustion • stoichiometric combustion • fuels • chemical • smouldering • diffusion • rapid • spontaneous • explosive. Concepts: • ventilation • flue draft • fuels.

Pipework technology (K1.17 – K1.19)	
Knowledge criteria	**Range and amplification**
K1.17 Types of pipework	Fittings and components and their use for different piping scenarios: • copper pipework • steel pipework • pliable corrugated (stainless steel) pipework • polyethylene (PE) pipework. The types of fixings available for the different materials.
	Underpinning Core Knowledge: C12.8
K1.18 Flow rates and their relationship to pipework and system design	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.
K1.19 Different techniques for forming and bending pipework	The different techniques for forming and bending pipework and how these are applied during the installation of gas systems/appliances: • bending machine • bending spring.
	Underpinning Core Knowledge: C12.8

Legislation and industry guidance (K1.20)	
Knowledge criteria	**Range and amplification**
K1.20 Implications of legislation, standards and manufacturer's instructions alongside additional guidance to employers and those working with gas systems	Current legislation, standards and manufacturer's instructions alongside additional guidance for installation of systems and the implications of these for employers and end users: • Gas Safety (Installation and Use) Regulations 1998 • Gas Industry Unsafe Situations Procedure (IGEM/G/11 Edition 2 with amendments July 2022 and June 2024) • Gas Safety Rights of Entry Regulations 1996 • Institution of Gas Engineers and Managers (IGEM) Standards • British Standards • Building Regulations • manufacturer's instructions • Gas Safe register • technical bulletins. [EC5]
	Underpinning Core Knowledge: C1.1, C1.3, C5.3, C5.7, C7.1, C7.4, C7.6

<table>
<tr><th colspan="2">Building technology (K1.21)</th></tr>
<tr><th>Knowledge criteria</th><th>Range and amplification</th></tr>
<tr><td rowspan="2">K1.21 Types of fixtures and suitability for different building fabrics</td><td>The various types of fixings, and their suitability for different building materials.

Fixtures:
• screws
• nails
• solid wall fixings
• plasterboard fixings
• security bolts.

Building fabrics:
• block walls
• brick walls
• wooden partitions
• plasterboard walls.</td></tr>
<tr><td>Underpinning Core Knowledge:
C7.5</td></tr>
</table>

<table>
<tr><th colspan="2">System installation (K1.22)</th></tr>
<tr><th>Knowledge criteria</th><th>Range and amplification</th></tr>
<tr><td>K1.22 Connection techniques</td><td>Types of jointing methods and processes and how to transition from one pipework material to another:
• threading
• soldering
• compression
• press-fit
• PTFE
• jointing compound.

Soldering must be lead-free in all applications.</td></tr>
</table>

System commissioning (K1.23 – K1.26)	
Knowledge criteria	**Range and amplification**
K1.23 Inspection techniques and how they are applied in commissioning systems	The factors to inspect during a visual inspection in line with manufacturer's instructions. [EC5]
	Underpinning Core Knowledge: C1.6
K1.24 Factors to inspect during commissioning, and how expected standards are defined	Factors to inspect during commissioning: • flow rate • temperature rise • combustion analysis • gas rate • installation operating pressure • standing pressure • appliance operating/ burner pressure • appliance condition • ventilation requirements • chimney / chimney system requirements • ventilation provision. How to interpret results and findings from commissioning tests. How expected standards are defined (manufacturer's instructions) and what actions to take if appliance/system is not functioning as expected. [MC2, MC6]
K1.25 Testing of installation	Critical testing that needs to be completed as part of installation and commissioning: • tightness test • flue flow test • spillage test • room sealed appliance (case seals) test.
K1.26 Safe storage and supply of fuel source	The safe storage and safe supply of natural gas (NG). The safe storage and supply of liquefied petroleum gas (LPG): • LPG cylinders • LPG bulk tanks.

System maintenance (K1.27 – K1.28)	
Knowledge criteria	**Range and amplification**
K1.27 Cleaning of components without compromising the system and associated tools, equipment and materials	Cleaning and servicing with consideration given to appropriate, techniques, tools and processes in line with manufacturer's recommendations and servicing schedules. [EC5]
K1.28 Fault-finding techniques, their suitability for different situations and how they are applied in practice	The process for carrying out fault-finding techniques: • safe isolation procedures (gas and electrical) • safe to touch procedures (electrical) • preliminary electrical testing • 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. Which techniques are suitable for different situations and how planned maintenance activities can minimise faults. [EC5, MC2, DC1, DC5]
	Underpinning Core Knowledge: C1.7

Decommissioning (K1.29 – K1.30)	
Knowledge criteria	**Range and amplification**
K1.29 Procedures involved in decommissioning	The processes and procedures involved in decommissioning gas systems.
K1.30 Requirements for recording, labelling and reporting decommissioned systems	Requirements for each system to record, label and report decommissioned systems to prevent the use of decommissioned appliance to include: • informing the responsible person • warning notices and labels. [EC4, EC5]

Outcome 2: Install gas systems (S2.1 – S2.22)	
Performance criteria	**Range and amplification**
S2.1 Interpret information from a risk assessment	Review and interpret risk assessments following HSE guidance. Consideration of employee’s versus employer’s responsibilities in relation to risk assessment completion. [EC4, EC5]
S2.2 Use tools in accordance with good working practice	Select the correct hand and power tools required to complete work activities on gas systems, taking into consideration safe use of the equipment and suitability of tools and equipment matched to the specific task: • pressure gauges • screwdriver • hammer • wood chisel • water pump pliers • spanner • spirit level • manual pipe threading machine • pipe cutter • pipe slice • hand saw • bending machine • bending spring • blowtorch • drill.
S2.3 Install pipework relevant to the type of gas being conveyed	Install gas pipework within or on the building fabric in line with current industry standards, building regulations and safe working practices. Pipework: • copper pipework/fittings • steel pipework/fittings • pliable corrugated (stainless steel) • pipework/fittings. Type of gas: • natural gas (NG) • liquefied petroleum gas (LPG). [MC1]

S2.4 Install clips/brackets to various substrates	Fix clips and brackets at recommended spacing intervals to meet the specification requirements and in line with current industry standards. Clips/brackets: • nail-on clip • plastic stand-off • brass Munson ring • steel Munson ring • meter brackets • flue brackets. Substrates: • wood • brick/block • plasterboard. [MC1]
S2.5 Install flues/chimneys to facilitate a range of gas appliances and equipment	Install a selection of flue types to different locations in line with current gas and building regulations and manufacturer's instructions, including the use of terminal guards as required: Flues/Chimneys: • open flues/chimneys (type B appliances) • room sealed flues/chimneys (type C appliances). Gas appliances: • open flued appliances (type B appliances) • room sealed appliances (type C appliances). [MC1]
S2.6 Install ventilators to facilitate the correct combustible air requirements for appliances installed in a variety of locations/buildings	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. Appliances: • space heater • boiler • water heater • gas cooker. Locations/buildings: • cavity walls • high level • low level • through two or more rooms. [MC1]

S2.7 Install appliances	Install gas appliances in line with manufacturer's instructions, following all installation instructions: • space heater • boiler • water heater • cooker. [MC1]
S2.8 Install components into appliances	Install a range of components into gas appliances: • multi-functional control valve/gas valve • fan • burner • pressure relief valve • automatic air vent • printed circuit board • air pressure switch.
S2.9 Install controls into systems	Install control components into a central heating system: • programmer • room thermostat • cylinder thermostat. [DC6]
S2.10 Install thermal insulation materials	Install various thermal insulation to prevent the freezing of system pipework: • polyisocyanurate foam pipework insulation • nitrile rubber pipework insulation • polyethylene foam pipework insulation.
S2.11 Install seals appropriate to the gas appliance	Check the condition of and replace different types of seal found in a gas appliance from a selection of seals. • combustion chamber/burner seals • gas seals • water seals. Appliances: • space heater • boiler • water heater • cooker.

S2.12 Check gas components are in accordance with design parameters	Use recognised testing methods (multimeters, gas rating, gas pressure testing) to ensure all components are within design parameters. Gas components: • thermistors • air/gas ratio control valves • thermostats • combustion performance analysis • gas valves. Design parameters: • resistance readings • pressure settings • temperature range • acceptable levels • manufacturer's parameters. [MC1, MC2, EC5]
S2.13 Check gas components are suitably certified	Check that gas components comply with manufacturer's requirements and are suitably certified (CE marking). [EC5]
S2.14 Analyse information to identify requirements for gas installation	Analyse customer requirements to identify the size of gas pipework and appliances to meet possible demand: • flueing requirements • ventilation requirements • pipe sizing requirements • heat output requirements. [EC5, MC2]
S2.15 Communicate system requirements to allied trades	Identify and communicate with other trades, detailing timescales and other system requirements: • electrical control requirements • hot and cold pipework layout • heating system pipework layout. [EC1, EC2, EC6]
S2.16 Establish safe working environment to conduct gas installation	Create a safe and clean working environment when installing gas systems and appliances: • well-ventilated area • no ignition sources • good housekeeping • temporary removal of meter • use of a temporary continuity bond • liaise with end user.
S2.17 Ensure no ingress of foreign objects within gas system and component	Install system pipework and 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.

S2.18 Update relevant line diagrams/installation plans	Complete a schematic/installation diagram of a gas carcass in a property, complete with pipe sizing and appliance gas rates. [MC1, MC2, MC6, MC7, EC1, EC2, EC3, DC2]
S2.19 Complete a method statement for installation and identifying any potential delays	Complete a method statement, identify the possibility of delays and unforeseen circumstances, and put systems in place to minimise risks. [EC1, EC2, EC3, MC1, MC2, MC10]
S2.20 Adapt onsite specific gas system installation changes	The necessary changes that need to be made if an appliance is to burn a different gas type: • LPG to natural gas. • injector sizes • ventilation requirements • notification.
S2.21 Gather relevant gas system component part information	Gather relevant documentation for working with gas systems and appliances: • manufacturer's instructions • normative documents • trade magazines • merchants. [EC5, EC6]
S2.22 Update digital building information management system software	Refer to and update digital building information management system software. [DC1, DC2, DC3, DC5, DC6]

Outcome 3: Commission gas systems (S3.1 – S3.12)	
Performance criteria	**Range and amplification**
S3.1 Assess risks associated with completing activities	Produce a risk assessment for commissioning activities in accordance with the six stages of assessment: • identify hazards • identify who is at risk and how • assess risk and action • record findings • review risk assessment • take appropriate safety precautions. Record risk assessment findings in line with regulations as well as responsibilities of employees versus employers. Risks: • explosive atmosphere, • carbon monoxide production • slips • trips and falls • crushing injuries • burns • cuts. [EC1, EC2, EC3, EC4]
S3.2 Test all gas rates and pressures are within regulatory requirements	Use recognised procedures to calculate the various gas rates and pressures required as well as the gas rate of the appliance: • operating pressure at the meter or regulator outlet where no meter installed (e.g. LPG) • the requirements of IGEM/G/13 2023 • operating pressure at the appliance • gas rates - metric meter, smart meter. Complete a gas rate and undertake gas pressures. [MC1, MC2, EC5]
S3.3 Ensure any tools/equipment are calibrated correctly	Calibrate tools and equipment correctly: • electronic combustion performance analyser • electronic pressure gauge. Consider requirements of electronic testing equipment and check if calibration is required and calibration certificates. [EC5]
S3.4 Calculate correct purge volumes in accordance with gas installation	Calculate purge volume and purge requirements, including: • calculating purge requirements to air • calculating purge requirements to burn. [MC1, MC2]
S3.5 Purge system correctly	Complete a safe purge of a gas installation to all industry standards.

S3.6 Visually inspect installation to ensure compliance with Gas Safety (Installation and Use) Regulations 1998 and appropriate standards	While completing gas work, the learner may encounter various non-conformance in the installation of gas pipework and appliances - therefore the learner must be able to identify 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 • incorrect appliance location • incorrect meter installation • incorrect terminal location • inadequate ventilation requirements • incorrect flueing requirements • incorrect gas type for appliance. [MC2, EC3, EC4, EC5]
S3.7 Complete gas system handover documentation to end user	Commission gas appliance/system and complete all commissioning documentation as required by the gas sector: • manufacturer's commissioning paperwork • industry recognised forms (Gas Safety Records, testing and purging form) • job sheet. [EC1, EC2, EC3, EC4, EC6, DC1]
S3.8 Demonstrate safe operation of gas appliance and controls to the end user	Instruct the customer on the safe and efficient use of all user controls during the handover process of the appliance/system including emergency actions (gas leak and what to do in the event of a carbon monoxide alarm sounding). [EC1, EC6]
S3.9 Visually check gas system installation conforms to original design requirements	Complete a visual check of gas system installation during handover/commissioning to the original system design as well as manufacturer's/regulatory requirements.
S3.10 Set gas system parameters to commission in accordance with manufacturer's instructions, appropriate standards and Gas Safety and Use Regulations 1998	Test gas system/appliance to ensure all measurements are within manufacturer parameters (pressure, temperature, flow rates, gas rate) and in line with the Gas (Installation and Use) Regulations 1998. Ensure appliance is commissioned following manufacturer instructions. [MC1, MC2]

S3.11 Record commissioning results	Complete a gas system/appliance commissioning record that is correctly documented using relevant technical terms and values. Record all commissioning checks on the commissioning record. [EC3, EC4]
S3.12 Analyse commissioning results to determine correct gas installation in accordance with original design	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 manufacturer's parameters. [MC2, MC6]

Outcome 4: Maintain gas systems (S4.1 – S4.8)	
Performance criteria	**Range and amplification**
S4.1 Question end user to identify any user concerns	Discuss maintenance requirements with end user /client with reference to other relevant available source materials (manufacturer's instructions/service history documents). User concerns: • risk assessments • smell of gas • carbon monoxide alarm sounding • using too much gas • appliance/system not working as intended • gas escapes • water leaks • noise. Advise on options for system/component maintenance and how it can best be achieved. Consideration should be given to potential barriers/concerns to overcome as well as to costs, sustainability and timescales. [EC1, EC2, EC3, EC4, EC5, EC6, MC2, MC6]
S4.2 Identify the correct replacement parts relevant to the appliance from a selection of similar parts	Select the correct replacement part from a selection of similar replacement parts to be fitted to a gas appliance/system: • multi-functional control valve • fan • burner • pump • plate to plate heat exchanger • main heat exchanger • automatic air vent • diverter valve/cartridge • pressure relief valve • printed circuit board.

S4.3 Calculate maintenance downtime	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. [MC2, EC1, EC6, DC3, DC5]
S4.4 Safe handling of all gas components when conducting maintenance	Handle gas components carefully when conducting maintenance: • smart meters • pre-payment meters • fragile components • dangerous components. In addition, the learner is also to be made aware of the possible injuries that may be sustained while working on gas systems/appliances.
S4.5 Identify potential gas installation system defects and follow unsafe situations procedure, as required	Identify a range of potential gas installation system errors and take the correct steps to ensure these are rectified following the unsafe situations procedure. Gas installation system defects: • 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 • incorrect gas pressures • incorrect gas rates • incorrect gas type • incorrect flame picture • incorrect parts used.
S4.6 Test system in accordance with end user requirements and appliance type	Complete critical testing of gas appliance/installations to ensure safety and compliance with end user requirements: • combustion performance analysis • tightness test (NG and LPG) • gas rate/heat input • hot water flow rate • standing pressure test • operating pressure test • ventilation check • flue flow test • spillage test • temperature/differential checks (balancing).

S4.7 Remove and replace faulty gas system components	Identify faulty gas system parts and components and remove and replace faulty component with new components in accordance with manufacturer's instructions: • meter regulator • air/gas ratio control valve • multifunctional control valve • burner • thermistor • thermostats • flame supervision devices • printed circuit board.
S4.8 Repair faulty gas system components	Repair faulty gas components ensuring they work to all parameters, with repairs to include: • blocked gauze on governor • thermocouple within a multifunctional valve • damaged leads.

Outcome 5 Decommission gas systems (S5.1 – S5.8)	
Performance criteria	**Range and amplification**
S5.1 Enable control mechanism from a risk assessment prior to working	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 • 'Do not turn on' information signs.
S5.2 Establish consumer needs when decommissioning any gas installation	Discuss with end user their needs when decommissioning any gas installation. Establish customer requirements, to maintain a temporary heating or hot water system. [EC1, EC3, EC4, EC6, DC3, DC5]
S5.3 Safely isolate the gas system prior to decommissioning	Complete safe and competent isolation procedures for the gas, electricity and water supplies when required, to include locking off and the placement of 'Do not turn on' information signs. Safely isolate: • isolate gas at the appropriate valve (emergency control valve (ECV) • additional emergency control valve (AECV)) • isolate electrical installation (if required) at appropriate point (main consumer unit, fused spur) • isolate water (if required) at appropriate isolation point • permanent or temporary isolation of the gas supply.
S5.4 Extract gas equipment and components from installation with appropriate handling techniques	Complete safe systems of work, risk assessments, method statements and select correct PPE when extracting equipment and components from installation.

S5.5 Reinstate appropriate service post decommissioning	Reinstate all utilities to the system post-installation to facilitate commissioning and handover: • re-pressurise heating system following a replacement part reinstate gas supply and test • reinstate electricity supply and test.
S5.6 Maintain safe working area	Maintain a safe and clean working environment when installing gas systems and appliances: • well-ventilated area • no ignition sources • good housekeeping • correct PPE.
S5.7 Return clean installation to end user	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 in situations where they have been re-commissioned following temporary decommissioning. [EC1, EC2, EC3, EC4, EC6]
S5.8 Safe disposal of waste products when decommissioning gas system	Ensure all waste products are disposed of safely when decommissioning a gas system: • asbestos • dust • packaging • appliances • pipework. Recycle as much waste as possible, remove any non-recyclable waste/hazardous waste and deposit at appropriate waste facility. Clean up any remaining mess.

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.

BSE 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
- Health and safety – BSE Regulations and safe working practices
- Building Services Engineering (BSE) systems – Boilers and fires
- Maintenance – Boiler service.

Guidance for delivery

Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery.

Formative assessment – oral Q&A, 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 Register Technical Bulletins
- CORGI Direct Manuals, Pocket Guides, etc.
- Level 3 Gas Engineer: Apprenticeship Training Manual (City and Guilds)
- Gas Installation Technology, RD Treloar, Wiley-Blackwell

Websites

- https://www.corgi-direct.com/city-guilds-qualifications-18169-0000
- Gas Safe Register https://www.gassaferegister.co.uk
- British Standards Institution https://shop.bsigroup.com/
- Institution of Gas Engineers and Managers https://igem.org.uk/
- Planning portal https://www.planningportal.co.uk/
- National Careers Service https://nationalcareers.service.gov.uk/job-profiles/gas-service-technician
- https://www.hse.gov.uk/pubns/books/l56.htm Gas Safety (Installation and Use) Regulations 1998 (GSIUR) as amended. Approved Code of Practice and guidance

Scheme of Assessment – Gas engineering

The Gas engineering occupational specialism is assessed by one practical assignment. The duration of the assessment is 24 hours. Learners will be assessed against the following assessment themes:

- Health and safety
- Design and planning
- Systems and components
- Inspect and test systems and components
- Report and information
- Handover and communication
- Working with faults.

By completing the following tasks:

Task	Typical knowledge and skills
Task 1 - Plan the installation	• Displays a breadth of knowledge and practical skills that enables them to carry out and plan for the installation of a gas system. Candidates will need to produce documents to industry standards that clearly states how they will carry out the installation.
Task 2 - Install and commission **Task 4 - decommission**	• Complete the given installation, commissioning and decommissioning tasks successfully. • The tasks are carried out in a clear and logical sequence. • Works in a safe manner, able to carry out testing and interpret and record test results accurately • Tools, materials and equipment are selected and used correctly. • Consideration to environmental sustainability and recycling of materials. Techniques used to make building fabric repairs to restore work area to pre-installation condition. • All work carried out in line with relevant manufacturer's instructions/ building regulations.
Task 3 – Carry out maintenance activity	• Applies knowledge and practical skills in rectifying a fault in a component or system. • Candidates will need to be able carry out, record and communicate maintenance activity with a customer.

The information provided in the following tables demonstrates to approved providers the weightings of each performance outcome and how each performance outcome is assessed.

Performance outcome and weighting (%)	**High level tasks** *Provide specific instructions for candidates to provide evidence for and are the same for every version of the assessment*	**Assessment Theme**	**Typical evidence**
PO2 Install gas systems (43%)	T1- Planning the installation	Health and Safety	Risk assessments, PPE, Working safely
	T2 – Install and commission	Design and Planning	Method statements, installation diagrams, material lists, selecting types of systems and components, measuring and marking out
	T1- Planning the installation	Systems and components	Using tools and equipment, cutting and bending pipe, jointing methods, prefabrication of pipe, positioning and securing component
	T2 – Install and commission	Reports and information	Interpretation of drawings, specifications, manufacturer instructions
	T1- Planning the installation T2 – Install and commission		

PO3 Commission gas systems (20%)	Task 2 - Install and commission Task 2 - Install and commission Task 2 - Install, commission and decommission Task 2 - Install and commission	Inspecting and testing systems and components Health and Safety Reports and information Handover/ communication	Soundness testing, leaks, commissioning checks Risk assessment, working safely, PPE Commissioning records Handover to customer
PO4 Maintain gas systems (20%)	T3 – Carry out Maintenance	Health and safety Working with faults Handover/ communication Reports and information	Risk assessment, working safely, PPE Fault diagnosis, client requirements, repair and replace components, use of tools Communication with customer to diagnose fault Maintenance activity report
PO5 Decommission gas systems (17%)	Task 4 - Decommission	Health and Safety Systems and components	Safe isolation process, safely isolate valves Extracting components, making good the building fabric, handling components and materials

Plumbing and heating engineering

Level	3
GLH	670
What is this specialism about?	This specialism aims to help learners understand and undertake fundamental plumbing and heating work. Learners will have the opportunity to plan, perform and evaluate their work while 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 plumbing and heating engineering work • Plumbing and heating tools and equipment • Pipework technology • Pipework materials, installation methods and jointing processes. • Plumbing systems and their purpose • Heating systems • Plumbing and heating engineering science • Principles of measurement and marking out components and pipework • Regulations, legislation and industry guidance used in the plumbing and heating industry. Note: Completion of the core and this occupational specialism provide threshold competence for entry into industry but does not provide full proof of occupational competence.
Learner preparation	Learners may be introduced to this specialism by asking themselves questions such as: • What does a plumbing and heating engineer do? • What tools and equipment do plumbing and heating engineers use as part of their role? • What skills are required in the role of a plumbing and heating engineer • What steps are required to become a qualified plumbing and heating engineer?
Underpinning knowledge outcomes	On completion of this specialism, learners will understand: 1. Plumbing and heating knowledge criteria
Performance outcomes	On completion of this specialism, learners will be able to: 2. Install plumbing and heating systems 3. Commission plumbing and heating systems 4. Maintain plumbing and heating systems 5. Decommission plumbing and heating systems

Maths, English and Digital skills	Completion of this specialism will give learners the opportunity to develop their Maths, English and digital skills. Where applicable, this information is included under the knowledge outcome, shown in square brackets.
Link to prior learning (Common Core)	Learners will build on their core knowledge and understanding by focusing on specialised knowledge required to work in and around plumbing and heating systems. Underpinning knowledge and understanding have been referenced in relation to the relevant knowledge outcomes.
Assessment method	Practical assignment.

Outcome 1 – Plumbing and heating common knowledge criteria
Learners will gain knowledge and understanding of the following content areas: Health and safety (K1.1 – K1.3) Tools, equipment and materials (K1.4 – K1.5) Plumbing and heating systems (K1.6 – K1.14) Measurement (K1.15) Plumbing and heating science (K1.16 – K1.24) Pipework technology (K1.25 – K1.29) Information and data (K1.30 – K1.31) System installation (K1.32 – K1.34) System commissioning (K1.35 – K1.39) System maintenance (K1.40 – K1.43) System decommissioning (K1.44 – K1.48)

Health and safety (K1.1 – K1.3)	
Knowledge criteria	**Range and amplification**
K1.1 Key requirements of Codes of Practice (CoP), Building Regulations and the Water Regulations	Codes of practice (CoP): • L8 Legionnaires' disease - the control of Legionella bacteria in water systems. Building Regulations Approved Documents: • part F – ventilation, • part G – sanitation, hot water safety and water efficiency, • part H – drainage and waste disposal, • part J – combustion appliances and fuel storage systems, • part L – conservation of fuel and power, • part P – electrical safety. Water Supply (Water Fittings) Regulations 1999. Current legislation/regulation and who is responsible for safety under relevant legislation and COP. The potential implications of non-compliance of: • general legislation • construction specific legislation

	• building services specific legislation including site safety card schemes. [EC5]
	Underpinning Core Knowledge: C1.1, C1.3, C7.2, C7.3

K1.2 Typical hazards and risks associated with plumbing and heating systems	Typical hazards:
	• tripping hazards
	• slipping hazards
	• inadequate or lack of personal protective equipment
	• defective (unsafe) equipment
	• manual handling
	• working at heights
	• chemical injuries
	• inhalation of gases/chemicals
	• transfer of bacteria.
	
	The controls that need to be in place to minimise hazards.
	
	Asbestos:
	• types
	• places you may come across asbestos
	• how to deal with asbestos.
	
	Electrocution.
	
	Common electrical dangers encountered on construction sites and in private dwellings:
	• faulty electrical equipment
	• signs of damaged or worn electrical cables – power tools and property hard wiring system
	• trailing cables
	• proximity of cables to services pipework
	• buried/hidden cables
	• inadequate over-current protection devices.
	
	Heat producing equipment.
	
	The various types of gases used in jointing processes:
	• propane
	• MAP gas
	• butane
	• oxy acetylene.
	
	Safe transportation and storage of bottled gases and equipment.
	
	The various types of heat-producing equipment and how to check them for safety and assemble:
	• hoses
	    • colours used
	    • thread directions
	    • flashback arrestors

	• dates • control valves • gauges • blowpipes. Safe: • bottle location and position • equipment assembly sequence • leak detection procedure • purging procedure • lighting and extinguishing procedure • actions in the event of leakage • transportation. The dangers of working with heat-producing equipment and how to prevent fires occurring. The method for fighting small/localised fires that can occur in the workplace. Fighting small/localised fires: • tackling fires to aid escape • types of extinguisher • selection of extinguisher by fire type • method of use • evacuation procedures.
	Underpinning Core Knowledge: C1.5, C1.10, C12.6, C13.2, C14.1
K1.3 Implications of legislation and additional guidance to employers and those working with plumbing and heating systems	Implications of legislation and additional guidance for employers and those working with heating systems including legal requirements and the consequences of not following the legislation. Workplace information: • statutory legislation • building regulations • job specifications • plans/drawings • work programmes • variation order • delivery notes • time sheets • policy documentation – health and safety, environmental, customer service • manufacturer guidance • installation instructions • service and maintenance instructions • user instructions. Company policies and procedures: • company working policies/procedures:

	• behaviour
	    • timekeeping
	    • dress code
	    • contract of employment
	• limits to personal authority
	• organisation/reporting structures
	• relevant qualifications and training.

	Underpinning Core Knowledge: C1.1

Tools, equipment and materials (K1.4 – K1.5)	
Knowledge criteria	**Range and amplification**
K1.4 Tools, equipment and materials used for installation	Tools: • screwdriver • hammer • chisel • water pump pliers • adjustable wrench • spanner • spirit level • pipe cutter • hand saw • plier • bending tool • soldering equipment • press-fit • tape measure • measuring equipment. Power tools: • power drill • circular saw • jig saw • reciprocating saws • multi tool • press fit gun • portable pipe threading machine • hydraulic machine bender • hydraulic crimping kit • portable pipe freezing kit. Equipment: • access equipment • digital measuring equipment. Materials: • copper pipework/fittings • plastic pipework/fittings.

	Common equipment and materials and their purpose. New and emerging systems, tools and technology to ensure currency of practice. Additional tools and equipment that can be used for adapted ways of working. How to store tools and equipment appropriately. The sources of information for carrying out preparatory work, to include: • statutory regulations • industry standards • manufacturer’s technical instructions • building plans • specifications. Preparation techniques to prepare the building fabric to include work methods and damage to property. Work methods: • holes in masonry surfaces – hammer and chisel, large power drill • making good to masonry surfaces • lifting and replacing timber flooring materials • notching timber floor joists • drilling holes – timber floor joists • cutting chases – wall and floor surfaces • walking boards • dust sheets • removal of personal property.
	Underpinning Core Knowledge: C2.3, C4.7, C7.1, C7.5, C7.6, C8.2, C12.8, C14.1
K1.5 Operation and handling requirements for tools and equipment	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 requirements. PPE requirements.
	Underpinning Core Knowledge: C1.11, C14.1, C14.2

Plumbing and Heating systems (K1.6 – K1.14)	
Knowledge criteria	**Range and amplification**
K1.6 Sources and distribution of water	Surface sources: • lakes • reservoirs • rivers • streams. Underground sources: • deep and shallow wells • artesian wells • bore-holes • springs. Supply and water treatment: • mains • private. Fluid categories: • 1–5 • preventing waste, undue consumption, misuse or contamination. Service to the property: • connection methods to the main • communication pipe detail • service pipe detail • main external stop valve location and meter housings • installation requirements • methods of entry of the service pipework to a property.
	Underpinning Core Knowledge: C2.10, C4.2, C5.4

K1.7 Plumbing and heating systems	Plumbing systems: Rainwater harvesting, rainwater systems Grey water re-use. The types of plumbing systems their purpose and key considerations for installation and maintenance. The advantages and disadvantages and working principles of different systems. The layout features, pipe sizes used and working principles of systems and components. Cold water systems: • direct cold-water system • indirect cold-water system • boosted. Components (cold water): • appliances • taps, outlets and valves • water meters • showers • water treatment • cisterns • boosted system components. Cistern layout and installation requirements. Backflow risk and methods of backflow prevention. Methods of backflow prevention to include: • non-mechanical types: AA, AB, AD, AG, AUK1, AUK2, AUK3, and DC pipe interrupter. • mechanical types: BA, CA, DB, EA/EB, EC/ED, HA, HUK1 and HC (4.4). Hot water systems and components: • vented • unvented. Rainwater systems and components: • half round • square • ogee • high capacity. Sanitation systems: • primary ventilated stack system • secondary ventilated stack system • ventilated branch discharge system • stub stack system.

	Below ground drainage systems:
	• combined drainage systems
	• separate drainage systems
	• partially separate drainage systems
	• soakaways, cesspits and septic tanks.
	
	Heating systems:
	• wet central heating:
	    • open vented heating systems:
	        • heat only boiler
	    • sealed heating systems:
	        • system boiler
	        • combination boiler
	• warm air
	• storage heaters
	• heat interface units
	• district heating.
	
	The different types of heating systems:
	• fully pumped, 2 x two port valves (S plan)
	• fully pumped, 3 x two port valves (S plan+)
	• fully pumped, 3 port valve (mid position/diverting) (Y/W plans (PDHWS))
	• combination boiler
	• system boiler
	• electric boiler
	• heat pump.
	
	Larger system control:
	• constant temperature
	• variable temperature.
	
	Layout features:
	• one pipe
	• two pipes
	• manifold (microbore, minibore)
	• underfloor heating
	• multiple boiler installation (low loss header).
	
	The advantages and disadvantages of types and layout features of heating systems.
	
	The typical pipe sizes used in central heating systems.
	
	The importance of pump positioning.
	
	Identify operating principles of controls for system operation.
	
	The zoning and control requirements of central heating systems in accordance with statutory legislation.

	The insulation requirements and system frost protection. The expansion and contraction in central heating systems and negative effects.
	Underpinning Core Knowledge: C12.3
K1.8 Components used in plumbing and heating systems	Components used in plumbing systems, their characteristics and function within the system and how they work together to support the operation of the system. Plumbing 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 / bidet / douche valves • basin • appliance trap • flushing syphons • water treatment • water softeners/conditioners/filters • booster pumps • accumulators • showers • dishwashers • washing machines • fridges • cylinders • domestic sprinkler systems • thermostatic mixing valves. Different components used in heating systems. How they operate to support the system operation. Positioning, fixing, connection and operation of components. Importance of correct pump positioning. Zoning and control requirements of central heating systems in accordance with statutory legislation. Insulation requirements of heating systems and components to ensure system frost protection and energy efficiency.

	How expansion and contraction is catered for in central heating systems, and the negative effects of pipework expansion. Heating components: Sealed system components • filling loop • pressure gauge • buffer vessels • pressure relief valves • expansion vessel. Open vent components: • feed and expansion cisterns • anti-gravity valves. Generic heating components • automatic air vents • circulating pumps • drain valves • low loss headers • expansion joints • corrosion filters • magnetic filters • zone valves (two port, three port, mid position and diverter) • low loss headers for multiple boiler installation • multiple heat producing appliances installation • bespoke heat emitters • panel radiators • column radiators • low surface temperature radiators • fan convectors • plinth heaters • towel warmers • underfloor heating components • manifolds • insulation • pipework • manifold isolation ball valves • additives – inhibitor, descaler, sludge remover, cleanser. Heating controls: • radiator valves – thermostatic and manual valves • thermo-mechanical cylinder control valves • programmer • timer • thermostats • programmable room stat • optimizer • weather compensation • optimum start • night set back

<table>
<tr><td rowspan="2"></td><td>frost stat
wiring centre
cylinder stat
automatic by-pass
pump control unit
smart controls.</td></tr>
<tr><td>Underpinning Core Knowledge:
C12.3</td></tr>
<tr><td rowspan="2">K1.9 Factors that affect the choice and suitability of components in a plumbing and heating system</td><td>Factors that affect the choice and suitability of components included in a system, taking into consideration current regulations, industry guidance and best practices.

Factors:
appliances
purpose
size
location
temperature
flow rate
pressure
environmental
customer needs
cost
end users’ needs
building regulation requirements
occupants
fuel availability
local availability.
[EC5]</td></tr>
<tr><td>Underpinning Core Knowledge:
C2.3, C3.2, C3.3</td></tr>
<tr><td rowspan="2">K1.10 Types of control systems required for plumbing systems</td><td>Types of control systems required for plumbing systems including digital controls, their characteristics, operation and suitability for different situations.

Control systems:
digital water controls
solenoid valves
infrared controls
water treatment.</td></tr>
<tr><td>Underpinning Core Knowledge:
C10.1</td></tr>
</table>

K1.11 Appliances supported by plumbing and heating systems	Common appliances connected to plumbing systems, their limitations, operating parameters, waste outputs and fluid categories. Plumbing appliances: • WC / bidet / douche valve • basin • bath • shower. Different types of appliances supported by heating systems, including their limitations, operating parameters and legal requirements. Procedures for filling and venting system types. Basic operating principles of heat-producing appliances. Heating appliances: • heat producing appliances • traditional boilers • condensing boilers • combination boilers • freestanding boilers • wall-mounted boilers • electric boilers • heat pumps • types of cylinder and ways of storing hot water (vented, unvented, thermal store).
K1.12 Types of waste and waste products and the associated systems and attributes	Main types of waste and waste products including types of systems. The hazards to the user and interaction with other parties, including the undertaker and treatment. Methods to reduce corrosion in heating systems. Methods to remove existing corrosion using chemical flushing and power flushing methods in heating systems. Systems: • septic tanks • wastewater lifters • macerators • heating systems. Attributes: • smells • bacteria • magnetite • corrosion.
	Underpinning Core Knowledge: C3.2, C5.4

K1.13 The effects of damage interference from external sources on system operation	Potential effects of damage interference from external sources on system operation. External sources: • electrolytic action • atmospheric corrosion • chemical damage • water damage • heat damage • mechanical damage • UV damage • freezing • cold • vibration.
	Underpinning Core Knowledge: C2.3
K1.14 Safety devices applicable to heating systems	Safety devices applicable to heating systems, their characteristics and operation. The typical operating pressures/temperatures of safety devices found in heating systems. Safety devices: • pressure/temperature relief valve • overheat thermostats • control thermostats. [MC2]

Measurement (K1.15)	
Knowledge criteria	**Range and amplification**
K1.15 Metric and imperial dimensions	The metric and imperial dimensions of height, weight, length and pressure. Metric and imperial dimensions: • metre (length) m • kilogram (mass) kg • feet • inches • centimetre • millimetre • bar (metric unit of pressure) • PSI (pounds per square inch, or pound force per square inch). [MC1 MC3 MC4]
	Underpinning Core Knowledge: C2.1, C2.2, C6.2

<table>
<tr><th colspan="2">Plumbing and Heating science (K1.16 – K1.24)</th></tr>
<tr><th>Knowledge criteria</th><th>Range and amplification</th></tr>
<tr><td>K1.16 Scientific principles and concepts to plumbing engineering</td><td>
Relative densities:

relative density to air
relative density to water.

Reasons for breakdown:

atmospheric corrosion
oxidisation 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.

Application of liquids:

water
refrigerants
anti-freeze/glycol mixes
fuel oils
lubricants/greases.

Gases:

air and steam
liquefied petroleum gas (LPG)
natural gas
carbon dioxide
refrigerant gases.

Properties of liquids:

water:

boiling/freezing point
relationship Celsius and Kelvin
change of state and molecular changes
volume and pressure increases
density at differing temperatures
to steam/super-heated steam
capillarity
acidity/alkalinity (pH value)
water hardness
soft

temporary hard
permanently hard.

Properties of gases:

natural gas, LPG and air

pressure
volume
temperature of gases found within the industry.

The types of water, properties and chemical states.
</td></tr>
</table>

	Water quality (including pH) and treatments. Scientific principles: • properties of solid materials • corrosion prevention. [MC4]
	Underpinning Core Knowledge: C2.3, C2.7
K1.17 Relationship between flow and pressure	Relationship between flow and pressure for both liquids and gases to include: • Boyle's law • Charles's law.
K1.18 Relationship between mass/volume and specific heat capacity	How to calculate specific heat capacity. How to calculate density. Heat capacity - calculate the quantity of heat energy required to raise the temperature of a substance and the amount of power required to heat a substance. Mass/volume - calculate the density of solids, liquids and gases. The density of water changes with the water's temperature. [MC2]
	Underpinning Core Knowledge: C2.2, C2.7
K1.19 Types of insulation materials	Types of insulation materials, their properties including relevant standards and current building regulations, and their suitability for different systems. Insulation materials: • polyisocyanurate foam • PVC foam • polyethylene foam.
	Underpinning Core Knowledge: C7.2, C7.3
K1.20 Electrolyte qualities of materials and the periodic table	Electrolyte qualities of materials: • the type • installation • size of pipework and fittings • their effect on flow rates.
	Underpinning Core Knowledge: C2.3, C12.8

<table>
<tr><td>K1.21 Scientific principles and concepts of heating engineering</td><td>The application of scientific principles and concepts to heating engineering.

Be able to calculate:
• quantity of heat energy required to raise the temperature of a substance
• the amount of power required to heat a substance
• simple force and pressure calculations.

Force and pressure:
• force calculations
    • pressure head
• pressure calculations
    • static pressure
    • dynamic pressure
    • draught
    • forced draught.

Velocity, pressure and flow rate:
• effects of increasing/reducing pressure
• effects of increasing/reducing pipe size.

Restrictions:
• changes of direction, bends and tees
• pipe size
• pipe reductions
• roughness of material surface
• constrictions, such as valves
• expansion in systems.

Scientific principles:
• heat transfer
• conduction
• convection
• radiation
• heat loss.
[MC4]</td></tr>
<tr><td></td><td>Underpinning Core Knowledge:
C2.3, C2.7</td></tr>
<tr><td>K1.22 Heating systems and the combustion process</td><td>The main constituents of complete and incomplete combustion for a range of fuels:
• gas
• oil
• solid fuel.

The causes and signs of incomplete combustion.

Combustion:
• complete combustion
• incomplete combustion
• combustion triangle.</td></tr>
<tr><td></td><td>Underpinning Core Knowledge:
C1.10</td></tr>
</table>

K1.23 Flues/Chimneys in relation to gas and the combustion process	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. Basic inspection requirements of flue systems. Operating principles: • remove combustion products • draw in combustion air. Components: • primary flue • draught diverter • secondary flue • terminal. Flues/chimneys: • open flued • room sealed • flueless.
K1.24 Ventilation in relation to gas and the combustion process	Ventilation requirements in relation to gas and the combustion process including the purpose, types and installation practices of providing ventilation. Types of ventilation: • natural • mechanical. Installation practices: • adequately sized • continuous size • sleeved • permanently open • fly screen removed • correctly positioned.

<table>
<tr><th colspan="2">Pipework technology (K1.25 – K1.29)</th></tr>
<tr><th>Knowledge criteria</th><th>Range and amplification</th></tr>
<tr><td rowspan="2">K1.25 Characteristics of types of pipework</td><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.

The positioning and fixing of pipework within the building fabric.

Pipework:
prefabricated components
modularised components
onsite installation.</td></tr>
<tr><td>Underpinning Core Knowledge:
C2.3, C7.5, C12.8</td></tr>
<tr><td rowspan="2">K1.26 Types of pipework</td><td>Pipework materials and sizes used in buildings, where the materials may be used appropriately including some of the materials used for condensing and waste pipework.
copper
R220 soft coils
R250 half hard lengths
R290 hard lengths
plastic pipework
polyethylene (MDPE)
cross-linked polyethylene (PEX)
polybutylene
PVC-u
polypropylene
MUPVC
ABS
lead.</td></tr>
<tr><td>Underpinning Core Knowledge:
C2.3, C7.5, C12.8</td></tr>
<tr><td>K1.27 Jointing methods</td><td>The methods of jointing new pipe to existing lead pipework.

Methods of jointing pipework:
copper pipe:
solder ring and end feed
compression (type A and B)
push-fit
press-fit
plastic pressure pipe:
push fit
compression
proprietary - copper and MDPE.
plastic jointing (sanitary for condense):
ring seal
compression</td></tr>
</table>

<table>
<tr><td></td><td>• solvent.

Methods of bending pipework:
• copper machine bending:
    • 90° bends
    • sets and offset bends
    • passover bends.
• copper spring bend
• plastic pressure pipe:
    • spring bend
    • cabling technique
    • cold forming bend.</td></tr>
<tr><td rowspan="2">K1.28 Types of fitting</td><td>The different types and use of fitting and their suitability for different applications/material types.

Fitting:
• couplers/sockets
• elbows and bends
• equal tees
• reducing tees
• reducers
• tap connectors
• flexible connectors
• manifolds
• tank connectors
• nipples
• unions.</td></tr>
<tr><td>Underpinning Core Knowledge:
C2.3, C7.5</td></tr>
<tr><td rowspan="2">K1.29 Types of support, fittings and fixings</td><td>Different types of pipework support and fixings, and their suitability for different systems, purposes and building fabrics.

Support:
• saddle clip
• Munson ring
• plastic clip
• waste pipe clip
• soil pipe clip
• nail in clip
• gutter and rainwater clips.

Fixings:
• cavity fixings
• nails
• screws
• wall plug
• appliance fixing kit
• anchor bolts.</td></tr>
<tr><td>Underpinning Core Knowledge:
C2.3, C7.5, C12.8</td></tr>
</table>

Information and data (K1.30 – K1.31)	
Knowledge criteria	**Range and amplification**
K1.30 Plumbing and heating drawing symbols and markings	Common drawing symbols and markings. [EC3]
	Underpinning Core Knowledge: C6.3, C8.4
K1.31 Types of documentation	Different types of documentation, the specific content of different documents and what they are used for: • commissioning record • maintenance record • delivery note • job specification • working drawings • work programme • plans • quotations and estimates • invoice • risk assessment • method statement. [EC3 EC5 MC1 MC2]
	Underpinning Core Knowledge: C1.4, C4.4, C4.11, C13.4

System installation (K1.32 – K1.34)	
Knowledge criteria	**Range and amplification**
K1.32 Bending techniques	Different types of bending techniques and when they would be used. Copper machine bending: • 90° bends • sets and offset bends • passover bends. Copper spring bend: • 90° bends • sets and offset bends. Plastic pressure pipe: • spring bend • cabling technique • cold forming bend. The equipment used to carry out accurate bending of copper. Bending techniques: • scissor • pre-formed.

<table>
<tr><td rowspan="2">K1.33 Connection techniques</td><td>Different types of connection techniques during the installation and maintenance of plumbing systems and where and when to use them.

Solder and solder ring should be lead-free.

Copper pipe:
• solder ring and end feed (lead free)
• compression (type A and B)
• push-fit
• press-fit.

Plastic pressure pipe:
• push fit
• compression
• proprietary
• copper and MDPE.

Plastic jointing (sanitary):
• ring seal
• compression
• solvent.</td></tr>
<tr><td>Underpinning Core Knowledge:
C2.3</td></tr>
<tr><td rowspan="2">K1.34 Potential impact of installation activities</td><td>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 during temporary loss
• completing work out of hours or when unoccupied – cost related disability (no sanitation services).

Impact:
• no water
• temporary loss of water
• delayed arrival of resource or materials.</td></tr>
<tr><td>Underpinning Core Knowledge:
C12.2</td></tr>
</table>

System commissioning (K1.35 – K1.39)	
Knowledge criteria	**Range and amplification**
K1.35 Inspection techniques	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. Inspection techniques: • visual inspection • pre commissioning checks. [EC5]
	Underpinning Core Knowledge: C1.6, C7.4
K1.36 Factors to inspect during commissioning	Factors to inspect during pre-commissioning, and how expected standards are defined in conjunction with manufacturer's instructions and industry guidance: • pipework installed as specified, positioned as drawing and plumb • appropriate brackets and supports fitted at specified intervals • joints cleaned and complete • valves/controls fitted as specified and positioned as drawing • fittings tight, flange bolts, unions, compression joints etc • commissioning/ test points fitted as specified and positioned as drawing • D.O.C fitted as specified and closed • valves set in the correct position • controls set in the correct position • pipework painted as necessary • sensitive items isolated or removed as necessary • pipework installed to accommodate insulation • sleeves fitted as necessary • heat emitters installed as specified and positioned as drawing • storage and expansion vessels installed as specified and positioned as drawing • appliances installed as specified and positioned as drawing • flues installed as specified and positioned as drawing • safety requirements adhered to • relevant people notified • relevant items cleaned wherever necessary • balancing of the heating system. An overview of the basic principles of the commissioning process and what activities are carried out should also be covered: • visual inspection • fill and vent • soundness test • flush • operational checks • commissioning documentation

	• handover procedure. Factors: • appropriate checks to be made before commissioning • principles of commissioning • temperature • flow rate • pressure. [MC2 MC6]
	Underpinning Core Knowledge: C7.2, C7.3, C7.4
K1.37 Testing techniques	The different testing techniques, when they are used and how they are applied in line with current industry standards. How to carry out testing and disposal of by-products safely. Soundness test to industry requirements on plumbing and heating system pipework and components: • initial fill • stabilisation • test to required pressure • check for leaks • check pressures after test period. Operational checks: • temperature • flow rate • pressure • controls. Testing techniques: • air testing • hydraulic pressure testing • safety component operation • soundness testing • performance testing. [MC2 EC5]
K1.38 Documentation required for commissioning and verification of commissioning	The different documentation required for commissioning and verification of commissioning, its content, and when and how it is used within the commissioning process. Documentation: • commissioning record • service sheet • warranty information • manufacturer's guarantees • self-certification. [MC2 EC5]
	Underpinning Core Knowledge: C4.12

K1.39 Technical information required for use by different stakeholders	The types of technical information and different stakeholders. Completion of technical information, and who to pass it on to once complete. Technical information: • handover pack • instructions • user guides • service requirements. Stakeholders: • client/customer • installer • tenant • end user. [EC1 EC3 EC4 DC2 DC3]	
	Underpinning Core Knowledge: C4.12, C5.3, C9.1	

System maintenance (K1.40 – K1.43)	
Knowledge criteria	**Range and amplification**
K1.40 Fault-finding techniques	The fault-finding process and techniques used to diagnose faults. The application of different techniques for different situations. The fault finding and rectification process on a range of plumbing systems including obtaining information on system faults from the end user with reference to manufacturer instructions. How to carry out diagnostic checks with reference to fault diagnosis flow charts. Fault-finding techniques: • end user discussions and questioning • consulting manufacturer's instructions • following fault diagnosis flow chart • checking service history • knowledge gained from industry experience. [EC5 MC2 DC1 DC5]
	Underpinning Core Knowledge: C7.4, C13.4, C13.5
K1.41 Causes of typical faults in plumbing and heating systems	Common faults in plumbing and heating systems, and how they are caused during normal operation. Repair and rectification procedures to deal with a range of typical faults found on a plumbing and heating system. Causes: • poor installation • inadequate design • user error • environmental factors appliance/component malfunction. Plumbing typical faults: • leak in 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 • incorrect backflow devices in relation to the fluid categories • lack of flow rate. Heating 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 • expansion vessel losing pressure. [MC2]
K1.42 Documentation required for maintenance and verification of maintenance activities	The different documentation required for maintenance and verification of maintenance activities. Know what information is required for each, how they are completed and when they are used. Documentation: • manufacturer's instructions • maintenance record • maintenance programme • maintenance checklist • service history • job sheets. [EC5]
	Underpinning Core Knowledge: C7.4, C13.2, C13.4
K1.43 Actions required when faults cannot be rectified	Rectification procedures to deal with a range of faults: • diagnose • notify client • safely isolate • decommission • rectify • re-commission • handover. The actions required when faults cannot be rectified: • safe isolation • report to responsible person. The potential implications to customer and business including: • time • costs • loss or temporary loss of industry operations • alternative provisions. Actions: • apply warning notices/signs • discuss next steps. [MC2 MC10 EC1 EC6]
	Underpinning Core Knowledge: C13.5

<table>
<tr><th colspan="2">System decommissioning (K1.44 – K1.48)</th></tr>
<tr><th>Knowledge criteria</th><th>Range and amplification</th></tr>
<tr><td rowspan="2">K1.44 Procedures involved in decommissioning systems</td><td>The decommissioning procedures, and own role and responsibilities.

Procedures for isolation and decommissioning:
• notify relevant person
• isolate 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.

Systems:
• above ground drainage
• below ground drainage
• rainwater harvesting
• grey water re-use
• rainwater systems
• hot water
• cold water
• heating systems.</td></tr>
<tr><td>Underpinning Core Knowledge:
C1.7</td></tr>
<tr><td rowspan="2">K1.45 Waste management procedures</td><td>Waste management procedures and own role and responsibilities.

Relevant procedure for type of waste.

Materials that can be recycled:
• metals
• plastics
• wood/cardboard.

Waste management procedures:
• licensed waste disposal
• waste carriers licence
• recycling
• specialist disposal
• transport of licenced waste.</td></tr>
<tr><td>Underpinning Core Knowledge:
C5.7, C5.8</td></tr>
</table>

K1.46 Safe removal of different types of waste from the working area	Methods used to safely remove different types of waste from the working area for both licensed and unlicensed disposal. Types of waste: • asbestos • materials • contaminated water • recyclable • non-recyclable.
	Underpinning Core Knowledge: C3.3, C5.3, C5.4, C5.8, C7.4
K1.47 Documentation required for decommissioning and verification of decommissioning activities	Documentation required for decommissioning and verification of decommissioning activities, their content and purpose. Documentation: • job sheet • decommissioning record sheet. Decommissioning activities: • domestic installations • industrial and commercial installations. [EC1 EC3 EC4 EC5]
K1.48 Requirements for recording, labelling and reporting decommissioned systems	Requirements for each system to record, label and report decommissioned systems to prevent the use of decommissioned appliance to include: • informing the responsible person • warning notices • labels. [EC1 EC3 EC4 EC6]

Outcome 2 Install plumbing and heating systems (S2.1 – S2.23)	
Performance criteria	**Range and amplification**
S2.1 Interpret risk assessments and related documentation	Review and interpret risk assessments following HSE guidance. Consideration of employer's versus employee's responsibilities in relation to risk assessment completion. The related documentation: • work permit • method statement • toolbox talks. [EC4 EC5]
S2.2 Select tools, equipment and materials	Select the correct hand and power tools required to complete work activities on plumbing and heating systems, taking into consideration the safe use of the equipment and suitability of tools and equipment matched to specific tasks. Tools: • screwdriver • hammer • chisel • water pump pliers • adjustable wrench • spanner • spirit level • pipe cutter • hand saw • pliers • bending tool • blowtorch. Materials: • copper pipework/fittings • plastic pipework/fittings.
S2.3 Measure site requirements and materials	Measure site requirements and calculate material requirements from plans/drawings. Measure fixings to pipework and plumbing components using appropriate available equipment (tape measure, laser measure). Record findings accurately using appropriate SI units for scale of task, in line with industry standards and practices. [MC1 MC2]

S2.4 Mark out requirements	Prepare the building fabric for the installation of pipework and plumbing components in line with building regulations and industry standards. Requirements: • notching timber floor joists • drilling holes – timber floor joists • pipework clipping distances. [MC1 EC5]
S2.5 Use hand and power tools	Use hand and power tools to secure and install plumbing pipework and appliances and 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). Tools: • power drill • hand saw • hydraulic machine bender • hydraulic crimping kit.
S2.6 Prefabricate pipes by bending to shape	Bend pipes to meet the needs of the pipework specification, use appropriate material (copper, plastic) and specific site considerations. Use appropriate bending equipment/bending machine safely and in line with manufacturer's instructions. Shape: • 90° angle • offset angle • passover.
S2.7 Cut pipes	Measure and cut pipework materials to required length as detailed in the job specification. Use appropriate cutting equipment with consideration for safety, materials and equipment available. Consider site restrictions such as space and potential mess when cutting ensuring burrs are removed and edges are chamfered. Pipes: • copper pipework • plastic pipework. [MC1]

S2.8 Connect materials using jointing methods	Connect pipework together using the appropriate jointing method for materials, equipment and safety requirements: Copper pipe: • solder ring and end feed (lead free) • compression (type A and B) • push-fit • press-fit. Plastic pressure pipe: • push fit • compression • proprietary • copper and MDPE. Plastic jointing (sanitary): • ring seal • compression • solvent. [MC1]
S2.9 Install clips/brackets to different types of building fabric	Install and fix pipework clips and brackets at recommended spacing intervals to meet specification requirements and in line with current industry standards. Identify the correct clip for the type of pipework being used. Pipework: • copper pipework • plastic pipework. Clips/brackets: • saddle clip • Munson ring • plastic clip • nail in clip • school board clips. Building fabric: • timber • masonry • plasterboard. [MC1]

S2.10 Install pipework relevant to the type of system	Install pipework relevant to the type of system to be worked on with consideration given to 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 such as lead-free plumbing. Identify installation requirements for pipework: • prefabrication of pipework • installing pipework in-situ • use of sleeves • timber joist notching • first and second fix • pipework protection. Pipework: • copper pipework • plastic pipework. [MC1]
S2.11 Install heating appliances	Position, install and secure appliances in line with specification requirements and current industry standards/working methods, following manufacturer's instructions. Install pipework to a pre-installed/pre hung boiler. Appliance: • system boiler • combination boiler. [MC1]
S2.12 Install heat emitting devices	Install a heat emitting device with consideration given to appropriate fixing for material, installation equipment and safety requirements during installation. Heat emitting devices: • radiators • towel rails • skirting heaters • underfloor heating components.
S2.13 Install components to heating appliances	Install components listed in the range into pre-installed appliances in line with manufacturer's instructions Components: • diverter valves • safety controls • automatic air vents • circulating pumps.

S2.14 Install controls into a range of heating systems	Install components listed in the range into a range of systems in line with manufactures instructions. Controls: • timing devices – clocks and programmers • room thermostats • hot water thermostats • smart controls • zone valves • automatic bypass valves. [DC6]
S2.15 Install thermal insulation materials	Select appropriate thermal installation materials for installation taking into consideration the material and suitability. Thermal insulation materials: • polyisocyanurate foam • PVC foam • polyethylene foam.
S2.16 Install seals for heat emitting devices	Install seals for heat emitting devices in line with manufacturer's instructions including PTFE on radiator tails, rubber seals, vent points and blanks on a radiator.
S2.17 Check heating products are in accordance with design parameters	Carry out the following checks on heating products to ensure they meet system design parameters: • temperature • flow rate • pressure • functional testing of electrical and mechanical controls. Heating products: • radiator sizes • boiler size • zone valves • controls • pressure vessels • feed and expansion cisterns • circulating pumps. [MC1 MC2 EC5]
S2.18 Install control systems for the heating system	Install control systems for heating systems in line with manufacturer's instructions, current building regulations and British Standards. System: • fully pumped • 3 x 2 port valves (S plan Plus). [EC5]

S2.19 Position and secure components in plumbing system	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, manufacturer's instructions and British Standards. Use appropriate fixings to ensure security of components and check to ensure components are level and secure following positioning. 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. System: • direct and indirect cold water • boosted cold water • hot water • above ground drainage • below ground drainage • rainwater harvesting • rainwater systems • grey water re-use • unvented hot water cylinder. [MC1]
S2.20 Prepare a safe working environment to conduct plumbing and heating system installation	Prepare a safe working environment to conduct heating system installation by clearing the work area and ensuring correct storage of materials and equipment in line with industry practices, referring to health and safety documentation: • risk assessment • method statement • clear working area • site survey. [EC5]

S2.21 Interpret information provided	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. Information: • plans/drawings • job specifications • work programmes • installation instructions • local site considerations. [EC2 EC5 MC7]
S2.22 Update line diagrams/installation plans	Update line diagrams/installation plans following heating installation. There is no requirement to create an installation/system plan within the system - updating of basic data as part of a planning review is all that is required. [MC1 MC2 MC6 MC7 EC1 EC2 EC3 DC1 DC2 DC5]
S2.23 Update digital building information management system software	Update basic information within a digital building information management system following plumbing and heating installation. There is no requirement to create an installation plan/system plan within the system - updating of basic data as part of a planning review is all that is required. [DC1 DC2 DC3 DC5 DC6]

Outcome 3 Commission plumbing and heating systems (S3.1 – S3.12)	
Performance criteria	**Range and amplification**
S3.1 Assess risks associated with completing activities	Produce a risk assessment for commissioning activities in accordance with the six 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 employees versus employers. [EC1 EC2 EC3 EC4]
S3.2 Interpret information and data	Interpret data from visual and other sources including manufacturer's instructions, building regulations, drawings and BS-EN standards in order to correctly carry out the commissioning process. The importance of reference to accurate/current sources, currency of standards and guidance documents and whether they are subject to change. [EC5 MC6 DC3]
S3.3 Inspect the installation of components	Carry out visual inspection of systems and 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. [MC2 EC3 EC4 EC5]
S3.4 Set heating controls	Set the heating controls and parameters in accordance with manufacturer's technical instructions and end user requirements. Heating controls: • programmer • time clock • thermostats • programmable room stat • optimiser • smart controls. [EC5]
S3.5 Verify fitness for purpose of tools/equipment	Verify fitness for purpose of tools/equipment using a known source. Tools/equipment: • thermometer • voltage indicating device. [EC5]

S3.6 Test systems	Perform appropriate soundness tests, in line with current industry requirements, on installed systems and components, with consideration given to materials used and testing methods. Identify information sources required to complete testing and commissioning. Soundness test: • visual inspection • notify • initial fill • stabilisation • test to required pressure • check for leaks • check pressures after test period • complete documentation and notify as required. Pipework: • metal pipework • plastic pipework. Flushing requirements: • hot • cold • disinfection. System additives: • neutralisers • cleanser • water softener (salt) • descaler • desludgers • inhibitor. Systems: • cold water • hot water • sanitation • rainwater • heating system. [MC1 MC2 EC5]

S3.7 Ensure accuracy and compliance with intended outcomes	Carry out operational checks required during commissioning. Commissioning procedure: • visual inspection • fill and vent • soundness test • flush • operational checks • commissioning documentation • handover procedure. Intended outcomes: • temperature • flow rate • pressure • electrical controls • mechanical controls • functional testing.
S3.8 Adjust heating system parameters to commission	Adjust heating system parameters to commission in accordance with manufacturer's instructions. [EC5]
S3.9 Record data from commissioning checks	Measure and record system information using recognised methods in line with the requirements of current building regulations. Checks: • temperature • flow rate • pressure • operation of controls • functional checks. [EC3 EC4]
S3.10 Compare commissioning results against design parameters	Compare commissioning results against design parameters to determine correct installation in accordance with original design, ensuring efficiency and compliance with manufacturer's instructions.

S3.11 Complete required documentation and handover documentation	Complete system commissioning records to industry standards with the required information outlining the actions that must be taken when commissioning reveals defects. Be aware of the customer handover process. Documentation: • commissioning record • service sheet • benchmark/appliance certificates. Handover documentation: • handover pack- instructions • user guide • warranty information. [EC3 EC4 MC7]
S3.12 Present technical information orally for different stakeholders	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 (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. [EC1 EC2 EC3 EC4 EC5 EC6 MC2 MC6]

Outcome 4 Maintain plumbing and heating systems (S4.1 – S4.10)	
Performance criteria	**Range and amplification**
S4.1 Identify information requirements from a brief	Check all necessary job information is available before commencing the maintenance work with reference to manufacturer's requirements and guidance. Requirements: • end user • manufacturer's instructions • fault diagnosis flow chart • service history. [EC5 MC2 MC6]
S4.2 Explore end user or client requirements	Use open questioning and listening to discuss maintenance requirements with the end user or client with reference to other relevant available source materials (manufacturer's instructions/service history documents). Advise on options for system/component maintenance and how it can best be achieved. Consideration should be given to potential barriers/concerns, how to overcome them as well as to costs, sustainability and timescales. [EC1 EC2 EC3 EC4 EC5 EC6 MC2 MC6]
S4.3 Estimate and calculate time and resources	Interpret data from sources in order to make judgements on time and resources required for the maintenance process – equipment, materials and human resources. Consider potential impacts on the client and the business of inaccurate estimations and calculations. [MC2 MC6]
S4.4 Analyse situations to identify potential causes for delays and errors	Identify potential problems in relation to system maintenance procedures as a whole (not specific errors with a system) that may affect efficiency and completion (lack of resources, timescale issues, availability of materials/parts, site specific issues, specific client needs). Consider how best to mitigate these potential issues and whether risks can be removed or just minimised. [MC2 EC1 EC6 DC3 DC5]

S4.5 Inspect the suitability of materials, tools and equipment	Check tools, materials and equipment for suitability via visual inspection or relevant checks, including reporting and removal procedures for faulty or inappropriate items. Tools and equipment: • screwdriver • hammer • chisel • water pump pliers • adjustable wrench • spanner • spirit level • pipe cutter • circlip pliers • pliers • plunger • tap reseating tool • drain auger • drain rods • copper pipework/fittings • plastic pipework/fittings • pressure gauge • flow cup • thermometer.
S4.6 Conduct fault finding	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 the situation. Reference may also be made to manufacturer's instructions or specifications (fault-finding flow chart), service history and end user. [MC2 MC7 EC5]

S4.7 Repair component faults in plumbing and heating systems	Carry out the maintenance and repair of components as required, safely and in line with manufacturer's requirements and industry standards. Consider cost of repair versus replacement of component(s). Plumbing components: • taps-mixer or pillar • float valve • shower mixer valve • drain valve • WC siphon/drop valve • sanitary appliance trap • line strainer • control components • safety components. Heating components: • radiator valves – thermostatic and manual valves • timing devices – clocks and programmers • room thermostats • hot water thermostats • circulating pumps • filling loop • pressure gauge • expansion vessel • automatic bypass valve • automatic balancing valve.
S4.8 Engineer corrective measures to rectify faults in heating systems	Carry out safely and in line with manufacturer's requirements the repair and rectification procedures to deal with a range of faults. Faults: • pumping over • persistent venting • emitter cold spots • stuck TRVs • motorised valves not operating • expansion vessel failure blockages • pump failure • pressure relief valve • incorrect support to system pipework and components. [EC5]

S4.9 Disassemble plumbing and heating system components when conducting maintenance	System disassembly with safe isolation and strip down of plumbing and heating components following employer's and manufacturer's recognised process – systematically and with regard to minimising disruption and mess. Plumbing components: • WC flushing cistern • sink tap • wash hand basin tap • shower mixer valve • sanitary appliance trap • hot/cold sanitary pipework. Heating 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.
S4.10 Replace components within a plumbing and heating system	Replace components within a system as necessary to meet industry and task-specific requirements. Use safe and appropriate methods to dispose of replaced components. Plumbing components: • taps-mixer or pillar • float valve • shower mixer valve • drain valve • WC siphon/drop valve • sanitary appliance trap • line strainer • control components • safety components. Heating components: • heat emitters • pumps • zone valves • expansion vessel.

Outcome 5 Decommission plumbing and heating systems (S5.1 – S5.10)	
Performance criteria	**Range and amplification**
S5.1 Safely isolate valves/services to types of systems	Procedures for isolation and decommissioning: • notify the relevant person. • isolate 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. Types of system: • cold water • hot water • sanitation • heating. [EC1 EC2 EC3 EC4 EC5 EC6]
S5.2 Apply control mechanisms from a risk assessment prior to working	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. Procedure for decommissioning: • 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. Control mechanisms: • safe disposal of heating system fluids • safe isolation of fuel. [EC5]

S5.3 Communicate with user to establish needs when decommissioning plumbing and heating systems	Discuss decommissioning requirements with end user, taking into consideration end user needs. Needs: • temporary heating requirements • duration • hot water requirements. [EC1 EC2 EC3 EC4 EC6 DC3]
S5.4 Safely electrically isolate the plumbing and heating system prior to decommissioning	Safely isolate the heating system following the recognised safe isolation procedure and using the correct equipment. The six-step safe isolation procedure: • identify • isolate • prove • test • re-prove • lock.
S5.5 Handle materials to protect their integrity and safety	Handle materials to protect their integrity and safety during decommissioning. Adopt safe storage of components and materials following health and safety procedures. Materials: • components • pipework materials.
S5.6 Extract components and equipment from plumbing and heating systems	Remove pre-installed components from plumbing systems following recognised industry practices. Plumbing 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 • cylinders. Heating equipment: • boiler • radiators • components.

S5.7 Reconfigure systems	Reconfigure plumbing systems during the decommissioning process, ensuring the system is left in full working order.
S5.8 Reinstate appropriate service post-decommissioning	Reinstate appropriate services in the range post decommissioning, ensuring safety for the end user and compliance with industry standards. Service: • electricity • water • fuel.
S5.9 Make good the building fabric	Use construction materials to make good the building fabric following component or system removal - filling holes with plaster, removing waste build materials.
S5.10 Safe disposal of waste products when decommissioning heating systems	Categorise the waste produced during the decommissioning process in line with waste management plans and environmental policies. Methods including licensed waste disposal, Waste Carriers Licence, recycling, specialist disposal – asbestos and other forms of hazardous waste. [EC5]

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.

BSE 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
- Health and safety – BSE Regulations and safe working practices
- Building Services Engineering (BSE) systems – Cold water, hot water, sanitation and drainage, and heating
- Tools and equipment – Use and maintenance

Guidance for delivery

Opportunities for visits/engagement with local industry, employers and manufacturers should be provided throughout the delivery.

Formative assessment – oral Q&A, 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 and heating 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 and heating technology should be included in delivery where possible.

Suggested learning resources

Books
- Collins Complete Plumbing and Central Heating (Collins)
- Plumbing Encyclopaedia 4th edition RD (Treloar)
- Water Regulations Guide by **Laurrie Young** (Author), **Graham Mays** (Author)
- CORGIdirect Commercial Heating Manual - Non-Domestic - ND3 (CORGIdirect)
- CORGIdirect Central Heating - Wet and Dry Manual - GID7 (Latest Edition) (CORGIdirect)
- The Domestic Heating Design Guide (DHDG) - CIBSE

Websites

- WaterSafe https://www.watersafe.org.uk - https://www.wras.co.uk/
- National Careers Service - **https://nationalcareers.service.gov.uk/job-profiles/plumber**
- HETAS – Heating Equipment Testing and Approval Scheme - https://www.hetas.co.uk
- Chartered Institute of Plumbing and Heating Engineering (CIPHE) - https://www.ciphe.org.uk/
- Grundfos - https://uk.grundfos.com/
- Association of plumbing and heating contractors https://www.aphc.co.uk/
- Worcester Bosch - https://www.worcester-bosch.co.uk/
- Baxi - https://www.baxi.co.uk
- Danfoss - https://www.danfoss.com/en-gb/
- Planning portal - https://www.planningportal.co.uk/
- Oil Firing Technical Association – OFTEC - https://www.oftec.org
- British Standards Institution - https://shop.bsigroup.com/
- Domestic building services compliance guide – 2013 https://www.gov.uk/government/publications/amended-approved-document-l1b-and-domestic-building-services-compliance-guide
- HDVH domestic heating design guide CIBSI https://www.cibse.org/knowledge-research/knowledge-portal/domestic-heating-design-guide-2021/

Scheme of Assessment – Plumbing and heating engineering

The plumbing and heating engineering occupational specialism is assessed by one practical assignment. The duration of the assessment is 35 hours*.

Learners will be assessed against the following assessment themes:
- Health and safety
- Design and planning
- Systems and components
- Inspect and test systems and components
- Report and information
- Handover and communication
- Working with faults.

By completing the following tasks:

Task	Typical Knowledge and skills
Task 1 – Plan the installation	• Displays a breadth of knowledge and practical skills that enables them to carry out and plan for the installation of a plumbing and heating system. • Candidates will need to produce documents to industry standards that clearly states how they will carry out the installation.
Task 2 – Install and commission **Task 4 - Decommission**	• Complete the given installation, commissioning and decommissioning tasks successfully. • The tasks are carried out in a clear and logical sequence. • Works in a safe manner, able to carry out testing and interpret and record test results accurately. • Tools, materials and equipment are selected and used correctly. Consideration to environmental sustainability and recycling of materials. Techniques used to make building fabric repairs to restore work area to pre-installation condition. • All work carried out in line with relevant manufacturer's instructions/building regulations.
Task 3 – Carry out maintenance activity	• Applies knowledge and practical skills in rectifying a fault in a component or system. • Candidates will need to be able carry out, record and communicate maintenance activity with a customer.

The information provided in the following tables demonstrates to approved providers the weightings of each performance outcome and how each performance outcome is assessed.

Performance outcome and weighting (%)	**High level tasks** *Provide specific instructions for candidates to provide evidence for and are the same for every version of the assessment*	**Assessment Theme**	**Typical evidence**
PO2 Install plumbing and heating systems (36%)	T1 - Planning the installation T2 – Install and commission	Health and Safety	Risk assessments, PPE, Working safely
	T1 - Planning the installation	Design and Planning	Method statements, installation diagrams, material lists, selecting types of systems and components, measuring and marking out
	T2 – Install and commission	Systems and components	Using tools and equipment, cutting and bending pipe, jointing methods, prefabrication of pipe, positioning and securing component,
	T1 - Planning the installation T2 – Install and commission	Reports and information	Interpretation of drawings, specifications, manufacturer instructions

PO3 Commission plumbing and heating systems (24%)	Task 2 - Install and commission Task 2 - Install and commission Task 2 - Install and commission Task 2 - Install and commission	Inspecting and testing systems and components Health and Safety Reports and information Handover/ communication	Soundness testing, leaks, commissioning checks Risk assessment, working safely, PPE Commissioning records Handover to customer
PO4 Maintain plumbing and heating systems (23%)	T3 – Carry out Maintenance	Health and safety Working with faults Handover/ communication Reports and information	Risk assessment, working safely, PPE Fault diagnosis, client requirements, Repair and replace components, use of tools Communication with customer to diagnose fault Maintenance activity report
PO5 Decommission plumbing and heating systems (17%)	Task 4 - Decommission	Health and Safety Systems and components	Safe isolation process, safely isolate valves Extracting components, making good the building fabric, handling components and materials

Air conditioning engineering

Level	3
GLH	700
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 while 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 pipework to ensure it is leak-free • Fault-finding mechanical and electrical problems in air conditioning systems. Note: Completion of the core and this occupational specialism provide threshold competence for entry into industry but does not provide full proof of occupational competence.
Learner preparation	Learners may be introduced to this specialism by asking themselves questions such as: • What does an air conditioning technician do? • 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? • What skills are required in the role of an air conditioning technician?
Underpinning knowledge outcome	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: 1. Install air conditioning systems 2. Commission air conditioning systems 3. Maintain air conditioning systems
Maths, English and Digital skills	Completion of this specialism will give learners the opportunity to develop their Maths, English and digital skills. Where applicable, this information is included under the knowledge outcome, shown in square brackets.

Link to prior learning (Common Core)	Learners will build on their core knowledge and understanding by focusing on specialised knowledge required to work in and around air conditioning systems. Underpinning knowledge and understanding have been referenced in relation to the relevant knowledge outcomes.
Assessment method	Practical assignment

Outcome 1 – Air conditioning knowledge criteria
Learners will gain knowledge and understanding of the following content areas: Air conditioning systems (K1.1 – K1.2) Air conditioning science (K1.3 – K1.5) Legislation, Regulations and Standards (K1.6) Sustainability (K1.7 – K1.11) System installation (K1.12 – K1.16) System commissioning (K1.17 – K1.20) System maintenance (K1.21 – K1.25)

Air conditioning systems (K1.1 – K1.2)	
Knowledge criteria	**Range and amplification**
K1.1 The function and operation of air conditioning systems	The range of air conditioning systems in common use: • direct expansion • flooded (centralised plant, air handling units (AHUs) fan coils, chilled beams) • heat pump (ground, air and water source) • variable refrigerant volume (VRV)/ variable refrigerant flow (VRF) air conditioning • water chillers. The function and operation of air conditioning systems and how they interact in different systems and applications.
	Underpinning Core Knowledge: C12.1
K1.2 Air conditioning and ventilation in a modern economy	The uses of air conditioning and ventilation including the difference between cooling for human comfort and for process control in industry. What ventilation is, and how it can apply to air conditioning systems in terms of fresh air requirements or how it is used to effect air changes to remove stale, harmful or polluted air from a space.
	Underpinning Core Knowledge: C12.1

Air conditioning science (K1.3 – K1.5)	
Knowledge criteria	**Range and amplification**
K1.3 Scientific principles of air conditioning	Scientific principles: • thermodynamics • gas laws • psychometrics • fluid flow • electricity • filtration • heat transfer • properties of refrigerant fluids and lubricants. The principles of air conditioning science and how they apply to real life situations (gas laws and pressure testing, psychometrics and commissioning, heat calculations and heat transfer in system evaluation). 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's law • combined gas law • Dalton's law. Units of pressure: • Pascal • bar • millimetres of Hg • torr. Pressure scales: • absolute • vacuum • gauge. Primary refrigerants: • hydrofluorocarbons (HFC) • hydrofluoroolefins (HFO) • hydrocarbon (HC) natural refrigerants.

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Primary refrigerant ideal properties.

Secondary refrigerants and secondary refrigerants ideal properties.

Environmental impact.

Ideal properties of lubricants.

Filtration:

air filter (panel, bag, high efficiency particulate air (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.

The concept of temperature and temperature scales.

Convert values between temperature scales.

Calculate rate of heat transfer.

Range of variables and calculations:

cooling capacity
heating capacity
quantity of condensate over time.

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	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 versus velocity. [MC2, MC6]
	Underpinning Core Knowledge: C2.1, C2.2, C2.3, C2.7, C6.3
K1.4 Comfort in terms of temperature, humidity, carbon monoxide, metabolism	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).
	Underpinning Core Knowledge: C2.7
K1.5 Types of data	Types of data and how to apply them. The SI system of measurement and methods to apply to a range of calculations: Base units: • metre (length) m • kilogram (mass) kg • second (time) s • Kelvin (temperature) K • ampere (electrical current) A. Derived units: • area (m^2), • volume (m^3) • litres (L) • density (kg/m^3)

	• velocity (m/s) • acceleration (m/s^2) • pressure (Pascal) • specific volume (m^3/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) • psychrometric charts. Calculations: • pressure calculations (static and dynamic) • P = hpg, P =1/2pv2 • room heat gain calculation. Undertake heat load calculations for air conditioning and process heating and cooling applications. Use manual charts, and smartphone and PC based applications to ascertain pressure/temperature relationships. Undertake duct pressure and water systems pressure calculations (static and dynamic). Calculate room heat load. [MC4, MC6, MC7]
	Underpinning Core Knowledge: C2.1, C2,2, C6.2, C8.1

Legislation, Regulations and Standards (K1.6 – K1.11)	
Knowledge criteria	**Range and amplification**
K1.6 Relevant UK and international standards and Approved Codes of Practice (ACoPS)	Current health and safety and environmental legislation that apply to all aspects of the air conditioning industry Relevant current UK and international standards, and Approved Codes of Practice (ACOPS) related to air conditioning systems including indoor air quality, bacteria in water and asbestos: • Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) • F-Gas Regulations • Montreal Protocol 1989 • Indoor Air Quality (IAQ) Guidelines • ACOP L8 – Legionnaires' disease: The control of legionella bacteria in water systems • HSG274 Legionnaires' disease: Technical guidance. [EC4, EC5]
	Underpinning Core Knowledge: C1.1, C1.3, C5.3

Sustainability (K1.7 – K1.11)	
Knowledge criteria	**Range and amplification**
K1.7 Environmental technologies employed in the sector	The various energy efficiency methods used to reduce power consumption and environmental impact, reducing heat gain, cooling load or energy use: • cross-flow heat exchangers • thermal heat recovery wheels • run-around coils • capacity controls • inverter controls. Building management systems (BMS) to manage energy consumption through load shedding. Use of standard capacity controls to increase efficiency. Inverter control to give infinite load positions and maximise efficiency. Use of high efficiency heat exchangers, run around coils and other means for heat recovery and dehumidification. Keeping systems maintained and clean improves efficiency.

	Operating systems at the most efficient evaporating and condensing temperatures improves volumetric efficiency.
K1.8 Supply and storage of energy from renewable resources	Supply and storage of energy from a range of renewable energy sources: • wind power • solar power • solar thermal • solar photovoltaic • hydroelectric • electric storage • thermal storage • biofuels • tidal power • battery storage • waste to energy projects. Mechanical generation of electricity principles and its application to renewable resources, to include hydroelectric, tidal and wind power. Mechanical generation of electricity as applied to biofuels and waste to power systems. The use of photovoltaics to generate electricity, and solar power to heat water and other fluids. How batteries store electricity and their use in storing daylight generated power (photovoltaics). Demand side response (DSR)/demand side management (DSM).
	Underpinning Core Knowledge: C5.1, C5.10
K1.9 Air conditioning design to reduce environmental impact	Use of low GWP refrigerants, 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). Powering air conditioning systems with electricity from renewable or low polluting sources. The use of adiabatic cooling systems in geographically suitable areas. Design of hardware with greater life expectancy and guarantee of replacement parts.

	Increasing the insulation values of buildings and reducing electricity consumption.
	Underpinning Core Knowledge: C3.1, C5.1, C5.10
K1.10 The principles of operation of heat pumps	The operation of heat pumps using a pressure enthalpy chart and compare potential heat pump efficiency against traditional heating methods, to include: Heat pumps: • ground source • air source. Traditional methods: • gas boiler • electric heating.
	Underpinning Core Knowledge: C12.3
K1.11 Fundamental working principles of electrical controls and components and motor starting arrangements	The function and operation of the stated electrical controls and components and motor starting systems and their applications: Electrical controls: • pressure switches • thermostats • flow switches • over current/over temperature (bimetal, positive temperature coefficient (PTC), negative temperature coefficient (NTC) • relays (current, potential, solid state). Components: • single phase motors • coils • transformers • heaters • lights. Starting arrangements: • resistance start induction run (RSIR) • capacitor start induction run (CSIR) • capacitor start and run (CSR).

System installation (K1.12 – K1.16)	
Knowledge criteria	**Range and amplification**
K1.12 Checking multiple circuits and systems for leakages	How the current F-Gas Regulations, BS EN 378 and the application of gas laws relate to pressure testing and leak testing. The techniques for the safe pressure and leak testing of a system.
K1.13 Location methods for air handling system installation including types of tools and equipment needed	The methods and types of fixings used in the construction industry and how they can be used to mount air conditioning equipment: • wall/ceiling fixings • pipe benders • brazing equipment (LPG, oxy- acetylene) • pipe fittings • mechanical (flare, compression fittings) • braze jointing of pipework. The different types of pipe jointing methods and when one should be used as opposed to another (DSEAR).
	Underpinning Core Knowledge: C7.5, C14.1
K1.14 Types of ductwork and pipework	The different types of duct and pipes used in the RAC industry. When the different types would be applied: • pressure rating • space available. Ductwork: • plastic • steel • rectangular • circular • oval • rigid • flexible. Pipework: • copper • steel • aluminium • plastic. The different materials used in ductwork: • steel • aluminium • plastic.

	Underpinning Core Knowledge: C12.8
K1.15 Know the safety requirements for working with gases and heat producing equipment	The different types of fuel gases used to braze refrigeration and air conditioning pipework: • propane • butane • oxy-acetylene • nitrogen. Safety inspection before use and fire safety when performing brazing operations. Visual inspection: • inspection for general condition. Combustion: • three elements of the fire triangle. Dangers: • fires • burns • fumes • equipment damage • explosions.
	Underpinning Core Knowledge: C1.6, C1.10, C14.1
K1.16 Cable types and their termination	The different types of electrical cable used in air conditioning systems. The methods used to fix and terminate cabling safely: Cable types: • multi-core flex • steel wire armoured • single conductor • twin and earth • braided sheath cable • screened. Termination: • insulated crimps • non-insulated crimps.
	Underpinning Core Knowledge: C12.4, C12.7

<table>
<tr><th colspan="2">System commissioning (K1.17 – K1.20)</th></tr>
<tr><th>Knowledge criteria</th><th>Range and amplification</th></tr>
<tr><td rowspan="2">K1.17 System operation requirements to be checked for commissioning</td><td>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:
• running pressures
• temperatures
• superheat
• sub-cooling
• running current
• refrigerant charge
• leak testing.

In steady-state operation.

Record ambient temperature, refrigerant pressure data (also converted to temperature), the air on and off temperatures to all indoor and outdoor units, indoor room temperatures down to or up to set point, running amps at full load and when at normal room temperatures.

Data should be compared to design and adjustments made to meet expected design condition.

Test all end user controls.

Record refrigerant charged into system in addition to base charge.

Where possible, record subcooling and superheat.

Meet all F-Gas requirements.
[MC1, MC6]</td></tr>
<tr><td>Underpinning Core Knowledge:
C8.1</td></tr>
<tr><td>K1.18 Inspection of an air conditioning system</td><td>The process of carrying out an inspection to determine abnormal operation, unexpected operational noise:
• compressor
• fans
• bearings
• loose panels
• vibration
• oil seepage
• high temperatures
• disturbed wiring.</td></tr>
</table>

	How to use the human senses to determine fault conditions (sight, touch, hearing, smell). [MC2]
K1.19 Expectations of a steady-state condition for air conditioning and heat pump systems	Design parameters and steady-state conditions for different cooling and heating applications to determine the correct operating conditions. Determine the optimum running pressures and temperatures to meet the design parameters: • air conditioning • heat pump (ground coil and air source) • water chiller systems. [MC6]
K1.20 Know the impact of operating conditions on system performance	How system performance is affected when both internal and external environmental conditions change using a pressure enthalpy chart: • higher than design ambient temperatures • lower than design ambient temperatures for condensers and evaporators. How system performance is affected by common system faults using a pressure enthalpy chart: • blocked condenser • blocked evaporator • shortage of refrigerant • reduced air flow. [MC6]

System maintenance (K1.21 – K1.25)	
Knowledge criteria	**Range and amplification**
K1.21 Types of fault-finding techniques	Fault-finding techniques and how these are applied in practice: • use of senses (sight, sound, touch, smell) • previous site reports • customer information • commissioning data. The suitability of different fault-finding techniques determined by location, fault, refrigerant type and urgency for: • compact water chillers • process coolers • heat pumps (ground source and air source) • single split systems • multi split systems.

	The importance of comparing previous commissioning data to current data to identify faults and running conditions to determine if a fault condition exists. The use of senses, manufacturer's instructions and fault codes, and historical operating and commissioning data to determine and identify a fault condition. [MC2, MC6]
	Underpinning Core Knowledge: C8.2, C13.5
K1.22 Cleaning of components	The correct PPE and correct cleaning fluid for each component to ensure system is not compromised: Cleaning: • coil cleaning fluids • spray washers. Components: • evaporator and condenser coils • drain pan • pump • drain lines. Know and use the correct procedures: • safe isolation • 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.
	Underpinning Core Knowledge: C1.7, C1.11
K1.23 Disassembly techniques	When disassembling an air conditioning system for a repair activity, understand the importance of following: • safe isolation procedures • manufacturers recommendations and instructions • method statements.
	Underpinning Core Knowledge: C1.7
K1.24 Techniques according to use and operations of system	The difference between: • critical and non-critical systems (mortuary rooms and a domestic installation) • reactive (breakdown fault normally inspected and replaced at a preventative service including V belt) • preventive maintenance situations. How to prioritise which fault-finding techniques must be used.

	That reactive maintenance is usually a product of a policy of not employing preventative maintenance with the consequence that fault scenarios are often serious in terms of operation.
	Underpinning Core Knowledge: C13.1
K1.25 Referral of a fault to a specialist	How to determine if the fault-finding technique needs a specialist technician (F-Gas for charging and recovering refrigerant, electrician for electrical faults): • accessing the system • electrical work • refrigerant charging • refrigerant recovery • decommissioning. [MC2]

Outcome 2 Install air conditioning systems (S2.1 – S2.10)	
Performance criteria	**Range and amplification**
S2.1 Sequence and prioritise tasks	Interpret the customer's requirements and plan the installation to cause minimum disruption and liaise with other trades to avoid conflict. Plan execution of the programme of works, liaison with other trades, method statements and risk assessments. [EC1, EC4, EC5]
S2.2 Identify information requirements for the task	Identify and gather all the information needed from a range of sources to ensure compliance with local and national by-laws, current legislation and any specific manufacturer's requirements. Information requirements: • drawings • manufacturer's specifications • regulatory documents • industry codes of practice • manufacturer's instructions • installation specifications • permits to work • method statements • risk assessments • non-domestic building services compliance guide • building regulations • local by-laws. [EC4, EC5]
S2.3 Produce written reports to stakeholders about work completed	Produce written completion documentation for legal compliance and customer information. Reports: • handover information • operation instructions • F-Gas records • maintenance instructions • job sheet/card • commissioning record. [EC1, EC3]
S2.4 Measure and mark out installation requirements	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, with consideration for connection to services. Installation requirements: • pipe routes

	• location of air handling units • condensing units • connection to services (electricity, gas, water, drainage, ventilation). [MC1]
S2.5 Connect components	The connection of refrigerant, water supply and drainage pipework, electrical power and control cables and heating and cooling coils. Allowance should be made where any of the connections must also connect to external services. [MC1]
S2.6 Assemble pipework and insert components into system	Safely connect the specified range of components into the air conditioning, heat pump (ground or air source), water chiller or process cooler with consideration given to temperature sensitive components and make any electrical connections as necessary. 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. Join refrigeration pipework and components using brazing, flaring and swaging methods: • copper to copper (Cu to Cu) • copper to iron (Cu to Fe) • copper to brass (Cu to brass) • iron to brass (Fe to brass). Jointing methods: • similar and dissimilar metals with hot and cold joints • mechanical and compression • copper/aluminium (Cu/Al) joints.

	Prevent components from heat damage while brazing, and the application of pipe insulation materials: • wet rag • non-conductive foam • temporary removal of low melting point items. Fix: • vibration damping clamps • pipe saddles • pipe clips • insulated clamps. Purging using oxygen-free nitrogen (OFN) to prevent internal scaling.
S2.7 Adjust components	Adjust a range of components in accordance with manufacturer's instructions including: • pressure switches to set-point • mechanical and digital thermostats set to design value • superheat set on expansion valves to manufacturer's specification • evaporator pressure regulators set to correct pressure • fan speed controllers correctly set to maintain condensing temperature • drive belts adjusted to correct deflection • dampers set to design opening while checking damper fire control.
S2.8 Connect control systems	Connect a range of control components including sensors and programmers to the refrigeration and control circuit: • electronic controllers • head pressure controls • pressure/temperature transducers • building management systems • central control systems. Make safe electrical connections, as needed.
S2.9 Apply final settings	Calculate the correct additional charge for an air conditioning system in accordance with manufacturer's instructions.
S2.10 Confirm system is ready to commission	Carry out pre-commissioning checks before start-up of a system: • strength and tightness pressure/leak testing • electrical supply • electrical connections • temperature controllers • cabling.

Outcome 3 Commission air conditioning systems (S3.1 – S3.10)	
Performance criteria	**Range and amplification**
S3.1 Interpret a risk assessment	Interpret risk assessments with consideration for responsibilities and persons at risk, applying controls, and recording potential hazards and completion of documentation. [EC4, EC5]
S3.2 Interpret information provided	Interpret current regulatory, contractual and manufacturer's specifications and requirements in readiness to carry out system commissioning. Information: • BS EN 378 • F-Gas Regulations • contractual specifications • manufacturer's instructions • bill of materials • site plans. [EC4, EC5]
S3.3 Interpret commissioning data including determining design parameters have been met	Interpret data recorded that is downloaded and displayed on a storage device (bespoke controller, phone, PC) to ensure the design conditions and parameters (determined by the manufacturer or design engineer) are met. 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. [MC6, DC4]
S3.4 Explore requirements of the task	Use open questioning and listening techniques to ensure that the client's requirements and needs are met: • energy-efficiency requirements • heat recovery • required temperature and humidity • sound levels • air flow rates. [EC2, EC4, EC5, EC6]

S3.5 Visually inspect system installation	Conduct a visual inspection of the complete system to ensure cleanliness and 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.
S3.6 Establish a steady-state operation	Interpret the data readings recorded to ensure that the steady-state conditions achieved meet the contractual requirements: • running pressures • temperatures • running current • room temperature (dry and wet bulb). [MC6, DC3]
S3.7 Collect data from control system	Complete measurement of all required parameters to include temperatures, pressures, electrical currents and flow rates to ensure the system is running at maximum efficiency. Wet and dry bulb temperatures should be interpreted on a psychrometric chart or the digital equivalent to ascertain the condition of the measured air. Data: • primary and secondary refrigerant flow rates • temperatures • humidity and filtration/air quality levels. [MC5, MC6]
S3.8 Record data from commissioning instrumentation	Use commissioning instruments to collect and record data: • air quality • differential pressures • wet and dry temperatures • flows rates • running currents. [MC5, MC6, EC3]
S3.9 Check function of system against design specification	Use the measured commissioning data to adjust the air conditioning, heat pump, process cooler or water chiller system to achieve the required conditions and maximum energy efficiency. Use psychrometric chart or digital equivalent to determine air conditions. Function: • air quality • filtration • differential pressure • wet and dry bulb temperature • energy efficiency. [MC5]

S3.10 Adjust system to comfortable ambient conditions to ensure maximum performance and efficiency	Undertake appropriate testing and interpret data to adjust the system controls to achieve the correct environment conditions and maximise energy efficiency: • temperature • pressure controls • air flow rates • air distribution • energy efficiency. [MC6]

Outcome 4 Maintain air conditioning systems (S4.1 – S4.15)	
Performance criteria	**Range and amplification**
S4.1 Produce a method statement	Produce a method statement and risk assessment for either preventative or reactive maintenance through interpretation of system data, customer reports or contractual requirements. Method statement: • scope of works • manufacturer's instructions • contractual requirements • risk assessment • preventative or reactive maintenance • permits to work. [EC1, EC2, EC4]
S4.2 Assess the suitability of information available	Consider all of the information available with regard to its accuracy, sufficiency, currency and reliability before creating a maintenance plan. Information: • previous service records • F-Gas records • customer comments • senses • site logs. [EC4, EC5]
S4.3 Calculate resource requirements for servicing the systems	Consider the maintenance plan and manufacturers instruction to compile a list of all materials needed to complete the maintenance task. Assess fitness for purpose of all tools and equipment. [MC2, EC3]

S4.4 Complete documentation	Complete all documentation in line with contractual and current legislation requirements: • maintenance plan • maintenance report • F-Gas records. [EC3]
S4.5 Visually inspect systems	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 check for corrosion in fin and tube coils, water lines, drain pans, as well as the panels and metalwork containing the system; refrigerant or water leaks particularly in jointed sections of pipework or where vibration is present; damage, loose screws or connectors in the electrical terminal boxes, isolators and control panels.
S4.6 Clean systems	Carry out a wide range of cleaning activities with consideration given to health and safety and maintaining maximum energy efficiency: • indoor and outdoor coils • air filters • water filters • drain pans • drain lines • unit casings.
S4.7 Tighten loose components	Inspect, check and tighten all screws and connections, ensuring safe isolation procedure is followed before checking any electrical connections: • screws • nuts • bolts • electrical connectors • wall/ceiling fixings.
S4.8 Adjust components	Adjust a range of components in accordance with manufacturer's instructions including: • pressure switches to set-point • mechanical and digital thermostats set to design values • superheat set on expansion valves to manufacturer's specification • evaporator pressure regulators set to correct pressure • fan speed controllers correctly set to maintain condensing temperature • drive belts adjusted to correct deflection • dampers set to design opening while checking damper fire control.

S4.9 Lubricate bearings and other moving parts	Identify and lubricate all components within the scope of works to include: • pulley bearings • pumps • electric motors heat recovery wheels • fan motors.
S4.10 Check unit is running according to optimum settings	Use manufacturer's data or the design engineer's specifications compared with either data recorded manually or data downloaded from the specific system to ensure the system is running at optimum design conditions and maximum energy efficiency. Optimum settings: • manufacturer's instructions and specifications • recorded data (temperatures, pressures, currents) • client comments. Psychrometric calculations using a chart or digital equivalent may be required given the wet and dry bulb temperatures. [MC6, EC5]
S4.11 Review system against minimal risks from potential health hazards	Inspect the system with regard to other potential hazards: • sick building syndrome (SBS) • poor air distribution • blocked or missing air filters • static water (Legionella). Advise or take action as needed.
S4.12 Assess system risks for long term performance	Consider system information to make an assessment of potential life of system components and make recommendation or take action as necessary: • components reaching end of life • wear and tear • previous service reports. [MC2, MC6, EC5]
S4.13 Report on maintenance activities	Produce verbal and written reports based on the recorded data and the results of the inspection and works carried out: • job sheet/cards • F-Gas records • maintenance reports • verbal reports to client or supervisor. [EC1, EC2, EC3, EC4, EC6, DC2, DC1]
S4.14 Investigate system operation parameters to identify faults	Using a range of information and system data including the senses (sight, touch, hearing, smell) conduct fault analysis to investigate actual or potential faults: • commissioning data • manufacturer's data • system data (current and historical)

	• design parameters • refrigerant side • air flow • secondary refrigerant flow • electrical control function • site logs • previous service records. Construct a plan to put the system back into full operation. [MC2, MC6, EC4, EC5, DC4]
S4.15 Rectify system	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. [MC2, MC6]

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.

Guidance for delivery

There are opportunities to consolidate learning where elements of content are common across performance outcomes, for example:
- Jointing
- Charging
- Recovery.

Where content is common across installation, commissioning and maintenance activities, it is recommended 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, observation of measuring activities:
- Practical – use of pre-set formative assessment to carry out tasks and record on standardised form. Use of a variety of measuring instruments.
- 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 air conditioning classroom/workshop.
- A realistic representation of air conditioning systems and components should be installed in the classroom/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 air conditioning industry.
- New and emerging air conditioning technology should be included in the delivery.

Suggested learning resources

Books

- Refrigeration and Air-Conditioning (Hardcover – Illustrated) by Guy Hundy (Author)
- Refrigeration and Air Conditioning Technology (Motivate Series) by Norman Cook
- Modern Refrigeration and Air Conditioning by Althouse, Bracciano, Turnquist
- Refrigeration and Air Conditioning by A. R. Trott, T C Welch
- Air Conditioning Principles and Systems: An Energy Approach by Edward G. Pita.

Websites

- www.ior.org.uk
- BSEN378:2016 standard **BSI.Knowledge Shop**
- www.acrib.org.uk

F-Gas:

- www.gov.uk/government/collections/fluorinated-gas-f-gas-guidance-for-users-producers-and-traders
- www.refcom.org.uk

Centres should be aware of **Annex D: Industry placement supplementary recommendations (publishing.service.gov.uk)** which includes supplementary qualifications which will support learners' knowledge of health and safety requirements in this occupation, for example, F-Gas Category 1 Certificate.

Scheme of Assessment – Air conditioning engineering

The air conditioning engineering occupational specialism is assessed by one practical assignment. The duration of the assessment is 28 hours.

Learners will be assessed against the following assessment themes:

- Health and safety
- Design and planning
- Systems and components
- Inspect and test systems and components
- Report and information
- Handover and communication
- Working with faults.

By completing the following tasks:

Task	Typical knowledge and skills
Task 1 – Design	• Work from a specification to determine design calculations for a proposed installation. • Displays a breadth of knowledge and understanding in how system, environmental and customer needs can influence design requirements.
Task 2 – Plan the installation	• Displays a breadth of knowledge and practical skills that enables them to carry out and plan for the installation of an air conditioning system. • Candidates will need to produce documents to industry standards that clearly states how they will carry out the installation.
Task 3 – Install and commission	• Complete the given installation and commissioning task successfully. • The task is carried out in a clear and logical sequence. • Works in a safe manner, able to carry out testing and interpret and record test results accurately. • Tools, materials, and equipment are selected and used correctly. • Consideration to environmental sustainability and recycling of materials. Techniques used to make building fabric repairs to restore work area to pre-installation condition. • All work carried out in line with relevant manufacturer's instructions/building regulations.

Task 4 – Service and maintenance	• Complete the fault finding, decommissioning, rectification, and maintenance activities successfully. • Applies knowledge and practical skills in rectifying a fault in a component or system. • Candidates will need to be able carry out, record and communicate maintenance activity with a customer.

The information provided in the following tables demonstrates to approved providers the weightings of each performance outcome and how each performance outcome is assessed.

Performance outcome and weighting (%)	**High level tasks** *Provide specific instructions for candidates to provide evidence for and are the same for every version of the assessment*	**Assessment Theme**	**Typical evidence**
PO2 Install air conditioning systems (37%)	T1 - Design T2 - Planning the installation	Health and Safety	Risk assessments, PPE, Working safely
	T2 - Planning the installation	Design and Planning	Method statements, installation diagrams, material lists, Selecting types of systems and components, design calculations
	T3 – Install and commission	Systems and components	Using tools and equipment, cutting and bending pipe, jointing methods, prefabrication of pipe, positioning and securing component
	T1 - Design T3 – Install and commission	Reports and information	Interpretation of drawings, specifications, manufacturer instructions

PO3 Commission air conditioning systems (23%)	Task 3 – Install and commission	Inspecting and testing systems and components	Pressure testing, testing for leaks, commissioning checks
	T3 – Install and commission	Health and Safety	Risk assessment, working safely, PPE
	T3 – Install and commission	Reports and information	Commissioning records
	T3 – Install and commission T4 – Carry out service and maintenance	Handover/ communication	Handover to customer
PO4 Maintain air conditioning systems (40%)	T4 – Carry out service and maintenance	Health and safety Working with faults Handover/ communication Reports and information	Risk assessment, working safely, PPE Fault diagnosis, client requirements, Repair and replace components, use of tools Communication with customer to diagnose fault Maintenance activity report

Refrigeration engineering

Level	3
GLH	700
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 while 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 a refrigeration system to ensure it is leak-free • Fault-finding mechanical and electrical problems in refrigeration systems. Note: Completion of the core and this occupational specialism provide threshold competence for entry into industry but does not provide full proof of occupational competence.
Learner preparation	Learners may be introduced to this specialism by asking themselves questions such as: • What does a refrigeration technician do? • 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? • What skills are required in the role of a refrigeration technician?
Underpinning knowledge outcome	On completion of this specialism, learners will understand: 1. Refrigeration knowledge criteria
Performance outcomes	On completion of this specialism, learners will be able to: 1. Install refrigeration systems 2. Commission refrigeration systems 3. Maintain refrigeration systems
Maths, English and Digital skills	Completion of this specialism will give learners the opportunity to develop their Maths, English and digital skills. Where applicable, this information is included under the knowledge outcome, shown in square brackets.

Link to prior learning (Common Core)	Learners will build on their core knowledge and understanding by focusing on specialised knowledge required to work in and around refrigeration systems. Underpinning knowledge and understanding have been referenced in relation to the relevant knowledge outcomes.
Assessment method	Practical assignment

Outcome 1 - Refrigeration knowledge criteria
Learners will gain knowledge and understanding of the following content areas: Fluids (K1.1 – K1.2) Legislation, regulations and standards (K1.3) Refrigeration systems (K1.4 – K1.14) Sustainability (K1.15 – K1.18) System installation (K1.19 – K1.23) System commissioning (K1.24 – K1.26) System maintenance (K1.27 – K1.30)

Fluids (K1.1 – K1.2)	
Knowledge criteria	**Range and amplification**
K1.1 Types of fluids	How to identify the refrigerant state at different parts of the system covering saturated, superheated and subcooled conditions using temperature and pressure values around a refrigeration system. The range and differences between a primary and secondary refrigerant and a mineral and synthetic oil: • primary refrigerants (chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC), hydrofluorocarbons (HFCs), hydrofluoroolefins (HFO), hydrocarbons (HC), natural) • secondary refrigerants (glycols) • lubricants (mineral, synthetic) • refrigerant vapour/liquid • saturated refrigerant fluids. What miscibility is and how oils behave in various volume flow and fluid velocity situations and its impact on oil return to the compressor. Suction risers for oil return. Different types of liquids and gases, how they flow and the effect of different pipe sizes on flow. The effect of pressure drop on system performance and how it can change specific volumes of gases.

K1.2 The safe recovery, recycling and disposal of equipment and hazardous waste transfer	Classification of waste. Methods of safe recovery, recycling and disposal of equipment. The safe recovery of refrigerant (using the F-Gas regulations as a benchmark) from a system, for its re-use, its recovery for legal destruction and recovery for reclaiming and resale. Disposal of recovered fluids: • oil • ammonia-contaminated water • secondary refrigerants. Safe electrical isolation, and removal and disposal of waste electrical equipment. Current regulation and law applicable to waste disposal including the Environmental Protection Act 1990, F-Gas Regulation, and the Waste Electrical and Electronic Equipment (WEEE) regulations 2013. Mandatory paperwork associated with any hazardous waste transfer and refrigerant recovery.
	Underpinning Core Knowledge: C1.1, C1.8, C5.3, C5.7, C5.8, C7.2, C7.4

Legislation, regulations and standards (K1.3)	
Knowledge criteria	**Range and amplification**
K1.3 Key requirements of environmental legislation	The key responsibilities and requirements of current environmental legislation and their relation to refrigeration systems: • Climate Change Act 2008 • Control on Ozone-Depleting Substances • F-Gas Regulations • Environmental Protection Act 1990 • Hazardous Waste (England and Wales) Regulations 2005. The emphasis on phasing out of environmentally damaging refrigerants. Good practice of achieving zero leaks on refrigeration systems. Ensuring system pressure access is undertaken with minimal loss. [EC4, EC5]
	Underpinning Core Knowledge: C5.3

<table>
<tr><th colspan="2">Refrigeration systems (K1.4 – K1.14)</th></tr>
<tr><th>Knowledge criteria</th><th>Range and amplification</th></tr>
<tr><td rowspan="2">K1.4 Processes of refrigeration cycles</td><td>The laws of thermodynamics and their relationship to the refrigeration system and how heat is transferred to effect latent heat and sensible heat processes:
• temperature scales and their conversion (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 (superheating, sub-cooling)
• evaporation
• compression
• condensation
• expansion.

The four main components of the refrigeration system and their role in the cycle.

How the processes of heat transfer are accomplished.

How latent heat and sensible heat processes are vital to the efficient operation of the cycle.</td></tr>
<tr><td>Underpinning Core Knowledge:
C2.1, C2.2, C2.7</td></tr>
<tr><td>K1.5 Performance parameters for running a refrigeration cycle</td><td>Different refrigeration systems, including:
• cold storage (-20°C room temperature)
• blast freezing (-40°C, utilising individual quick freezing (IQF) blast freezers, spiral freezers, IQF tunnels)
• chilled storage (3°C including blast chilling)
• liquid chillers (utilising low -, medium - and high-temperature secondary refrigerants).

Performance parameters:
• suction and discharge pressures
• saturated suction / discharge temperatures
• superheat
• subcooling
• storage set-points
• running currents
• refrigerants (HFC, HC, HFO, natural).

Choice of refrigerants for different tasks (low -, medium - and high-temperature applications).

Optimising the system for the most efficient operation low condensing temperatures and high as possible evaporating temperatures for the application).

That optimised running conditions result in the least electrical consumption.</td></tr>
</table>

K1.6 Refrigeration system components	The function of a compressor. The operating principles of compressors: • reciprocating • screw • rotary • scroll • centrifugal. Their configurations (open, hermetic, semi-hermetic) and typical applications. The function of a condenser. The operating principle of condensers and their typical applications: • air cooled • water/liquid cooled • evaporative. The function of an evaporator. The operating principles of evaporators: • forced draft • induced draft • natural convection • liquid cooling • direct expansion • flooded. The function and operating principles of a metering device. Linked to metering devices, know the difference between expansion devices and feeds to an evaporator: • capillary tube restrictor • thermostatic expansion valves (internally and externally equalised) • linear/electronic expansion valves • liquid level control. The operating principles of a: • capillary tube restrictor • thermostatic expansion valve (internal and external equalisation) • electronic expansion valve (pulse and linear) • low-side float valve. The function and operating principles of a variety of ancillary devices including: • sight glasses • driers (suction and liquid line types), • pressure relief valves • strainers

	• service valves • oil separators. The function of system storage pressure vessel in industrial and commercial systems: • liquid receiver • suction accumulator • surge drum. The function and operating principles of control valves in industrial and commercial systems: • four-way reversing • solenoid • evaporator • crankcase • differential pressure regulators • non-return valves. The function and operating principles of fans along with the range of electric motors used to drive them: • axial • propeller • centrifugal.
	Underpinning Core Knowledge: C12.3
K1.7 Types of components for refrigeration systems	The different types of components and their suitability in different situations to meet differing client needs: • direct expansion • flooded • pump overfeed • cascade • compound • booster • trans-critical • blast freezing • cold storage • chill storage. Flooded evaporators and the need for a surge drum and associated level control system. Pumped overfeed systems, the importance of recirculation ratio and where such systems are used. Cascade systems, their operating principles, where they are used and common refrigerant combinations. Compound systems, the operating principles, and comparisons with single stage and economised operation particularly in terms of efficiency. CO_2 systems in trans-critical operation, where used, pressure range, triple point, and environmental factors.

	Blast freezing, typical design, expected evaporating temperatures and air velocity, commercial and industrial systems. Cold storage systems, system types, cold store temperature range (product and regulation dependent), and expected heat loads. Chill storage, the issues of product degradation due to improper conditions (temperature and or air flow), temperature range dependent on product.
K1.8 The operating principles for defrost systems	The different types of defrost systems used in the refrigeration industry and their control systems: • off-cycle • electric • hot gas • saturated gas. The operating principles for defrost systems, including: • initiation • termination • defrost sequence. Why defrost, the reasons ice accumulates on evaporator surfaces and the impact of ice on evaporator performance. Off-cycle defrost, use of low-pressure switch, thermostat, air flow pressure differential sensing and where used. Electric defrost, methods of initiation and termination, sequence of operation and determination of frequency. Hot gas defrost, uses sensible heat from discharge only, small systems including domestic refrigeration. Saturated (latent heat) defrost, system design, including reverse cycle, use in industrial and commercial systems.
K1.9 Methods to apply ideal gas laws	Methods to apply the gas laws for common refrigeration operations and when adaptations to a refrigeration system are needed: • Boyle's law • Charles' law • Gay-Lussac's law • Dalton's law • combined gas law. How the combined gas law is derived. Units of pressure: • Pascal • bar • millimetres of Hg

	• torr. Pressure scales: • absolute • gauge • vacuum.
	Underpinning Core Knowledge: C2.2
K1.10 How to show a refrigeration cycle on pressure-enthalpy charts	The pressure enthalpy chart, overview of the chart as a theoretical tool, its layout in terms of zones, identifying pressure, enthalpy temperature, specific volume, entropy and quality lines. Refrigeration cycle: • evaporation • compression • condensation • expansion processes • refrigeration effect • compressor work done • total heat rejection • dryness fraction • subcooling • useful and non-useful superheat. Gauge and absolute pressure conversion. Plot a refrigeration cycle on a pressure-enthalpy chart given system operating values and identify the key thermodynamic processes. These include work done by the compressor, evaporator and condenser. From the system plot calculate a range of variables which must include enthalpy, work done by the compressor, evaporator and condenser, identification of useful superheat and quality of the refrigerant at the metering device outlet.
K1.11 Interpret refrigeration data from pressure-enthalpy charts	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. 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). From the system plot calculate a range of variables, which must include: • enthalpy • specific volume at the suction inlet, • discharge temperature, • work done by the compressor, evaporator and condenser. Calculate coefficient of performance, identify useful superheat, quality of the refrigerant at the metering device outlet and compression (pressure) ratio. Additional calculations include system refrigeration capacity given a duty, refrigerant mass flow rate and compressor swept volume. [MC5, MC2, MC4]
K1.12 The properties of air and how they are changed by vapour compression systems	How a vapour compression system will alter the air temperature and moisture content and the effect this has on the storage of produce: • split system for a single room cooling application • fruit and vegetable chill store system • freezer cold room system.
K1.13 Ideal properties of refrigerant fluids and lubricants	The ideal properties of a range of primary refrigerants and lubricants and their uses for a range of refrigeration applications. Primary refrigerants: • HFC • HFO • HC • natural refrigerants. 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. The ideal properties of a range of secondary refrigerants and lubricants and their uses for a range of refrigeration applications. Secondary refrigerants: • water • propylene glycol

	• ethylene glycol • brines. Properties: • low viscosity • non-toxic • non-flammable • high specific heat value • low cost • non-corrosive • low freezing point. The 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. The use of only sensible heat and the limitations of such refrigerants and the implications for their use in refrigeration systems. The differences between pure fluid, azeotropic and zeotropic refrigerants. The hazard groups for toxicity and flammability: • A • B • 1 • 2L • 2 • 3 The environmental considerations: • ozone depletion • global warming/climate change.
	Underpinning Core Knowledge: C1.13, C5.3

K1.14 Types of monitoring systems	The different types of monitoring equipment and how they can be used to reduce the environmental impact of a refrigeration system: • local • remote • building management system (BMS) • pack control systems. The types of data produced by systems and how the data is produced and extracted. The different types of connectivity available.
	Underpinning Core Knowledge: C5.11, C8.1, C8.2

Sustainability (K1.15 – K1.18)	
Knowledge criteria	**Range and amplification**
K1.15 Environmental impact of refrigerants	The environmental impact that different refrigerants have on: • F-gas regulations • phasedown of refrigerants • climate change • ozone depletion potential (ODP) • global warming potential (GWP).
	Underpinning Core Knowledge: C5.3
K1.16 New developments in refrigeration	New developments in the refrigeration industry to reduce the environmental impact of refrigerant gases including using brazed joints and compulsory leak detection: • low GWP refrigerants (HFO, HC, Natural) • safety classifications. New refrigerants and their toxicity, fire risks and reduced environmental impact.
K1.17 Maximise efficient refrigeration system performance	Methods to maximise the efficiency of a refrigeration system through the selection of refrigerants and components, including inverters and PID controllers. How to set them up correctly to mitigate direct and indirect carbon emissions.

K1.18 Fundamental working principles of electrical controls and components and motor starting arrangements	The function and operation of the stated electrical controls and components and motor starting systems and their applications. Electrical controls: • pressure switches • thermostats • flow switches • over current/over temperature (bimetal, positive temperature coefficient (PTC), negative temperature coefficient (NTC)) • relays (current, potential, solid state). Electrical components: • single phase motors • coils • transformers • heaters • lights. Motor starting arrangements: • resistance start induction run (RSIR) • capacitor start induction run (CSIR) • capacitor start and run (CSR).

System installation (K1.19 – K1.23)	
Knowledge criteria	**Range and amplification**
K1.19 Methods for checking refrigeration system leakages	The methods used to check refrigeration systems for leakages in accordance with the current F- Gas Regulations and BS EN 378 for refrigerating systems and heat pumps - safety and environmental requirements: • strength and tightness testing • use of inert gases • electronic leak detection • leak test fluids • UV dye.
K1.20 Types of substrates	Health and safety implications of drilling into an unknown wall. The tools and equipment (power drills, types of drill bit) required for fixing a range of system components to a range of wall, floor and ceiling substrates: • insulated panels • brickwork • plasterboard • concrete. The implications for refrigeration system installation. **Underpinning Core Knowledge:** C7.5, C14.1

K1.21 Types of protective materials	The different types of thermal insulation material used to protect against heat gain/loss. Their properties and how to ensure the material operates effectively.
	Underpinning Core Knowledge: C2.7
K1.22 Types of pipework	Different types of pipework and their suitability for different purposes: • copper • steel • aluminium. How pipe characteristics affect refrigerant and oil flow.
	Underpinning Core Knowledge: C12.8
K1.23 Fix and terminate cabling	The different types of electrical cable used in the refrigeration industry: • multi-core flex • steel wire armoured • single conductor • twin and earth • braided sheath cable • screened. The methods used to fix and terminate cabling safely: • insulated crimps • non-insulated crimps.
	Underpinning Core Knowledge: C12.4, C12.7

System commissioning (K1.24 – K1.26)	
Knowledge criteria	**Range and amplification**
K1.24 System operation requirements	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 (superheating, sub-cooling, evaporator air on and off temperature, running currents, refrigerant type and quantity, condenser air on and off) • coil approach temperatures.

K1.25 Inspection of a refrigeration system	How to carry out an inspection using the human senses (sight, sound, smell, touch) to determine if fault conditions are present.
	Underpinning Core Knowledge: C1.6
K1.26 Expectations of a steady-state operation for refrigeration system	Expectations of a refrigeration system when it is running at the correct steady-state conditions, including after a long period of non-use. The checks required to confirm expectations including: • suction and discharge pressures • saturated suction/discharge temperatures • superheating • sub-cooling • storage set-points • running currents • refrigerant charge.

System maintenance (K1.27 – K1.30)	
Knowledge criteria	**Range and amplification**
K1.27 Types of fault-finding techniques	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: • use of human senses (sight, sound, smell, touch) • customer reports • historical records • manifold gauges • electrical test meters • safe electrical isolation.
K1.28 Cleaning of components	The components that require cleaning and how to clean without compromising the system: • coils • drain pans • drain lines. The tools, equipment and materials used to clean components - pressure washers and cleaning fluids.
	Underpinning Core Knowledge: C12.8

K1.29 Disassembly techniques	Considerations to safely disassemble a refrigeration system and its components prior to repair or replacement of individual components. Considerations to include: • use of tools • techniques (unbrazing, brazing) • safe electrical isolation • refrigerant recovery. Reference documents to include: • manufacturer's instructions • method statements • risk assessments.
	Underpinning Core Knowledge: C1.4, C1.7, C1.8, C7.4
K1.30 Methods to extract refrigerant	Methods to safely remove refrigerant from a system in accordance with the F-Gas Regulation and all current environmental legislation, Hazardous Waste Regulations: • recover • reclamation and recycling methods • safe electrical isolation. The purpose of Waste Transfer Notes, and methods to safely handle and manage refrigerant once extracted.
	Underpinning Core Knowledge: C1.8, C5.3, C5.4, C5.8, C7.2, C7.4

Outcome 2 Install refrigeration systems (S2.1 – S2.15)	
Performance criteria	**Range and amplification**
S2.1 Sequence and prioritise tasks	Interpret the customer's requirements, plan the installation to cause minimum disruption and liaise with other trades to avoid conflict. Plan execution of programme of works, liaise with other trades, method statements and risk assessments. [EC1, EC4, EC5]
S2.2 Identify information requirements from a brief	Identify all the information needed from a range of sources to ensure compliance with current local and national by-laws and legislation and any specific manufacturer's requirements: • drawings • manufacturer's specifications • regulatory documents • industry codes of practice • manufacturer's instructions • installation specifications • permits to work • method statement • risk assessment. [EC4, EC5]

S2.3 Gather required information	Gather all necessary information from a range of sources to ensure compliance with current local and national by-laws and legislation and any specific manufacturer's requirements: • manufacturer's instructions • non-domestic building services compliance guide • building regulations • local by-laws. [EC4]
S2.4 Interpret information and data	Interpret all the information gathered to plan the installation of the refrigeration system: • manufacturer's instructions • non-domestic building services compliance guide • building regulations • local by-laws. [EC4, EC5, MC6]
S2.5 Calculate data required	Calculate the heat gain into a cold room and determine the product cooling load as well as the ideal storage temperature. Data required: • heat gains in cold rooms • product cooling loads • component selection • ideal storage temperatures. [MC2]
S2.6 Produce written reports to stakeholders about work completed	Produce written completion reports and/or documentation for legal compliance (F-gas records) and customer information (operation instructions): • handover information • operation instructions • F-Gas records • maintenance instructions • job sheet/card • commissioning record. [EC1, EC3]
S2.7 Measure and mark out installation requirements	Mark out the location of indoor and outdoor sections of the system: • pipe routes • location of evaporator coils (coolers) • condensing units • services (electricity, gas, water, drainage, ventilation). [MC1]
S2.8 Drill holes for fixings in various substrates	Drill the correct size hole for a range of fixings in a variety of wall substrates: • insulated panels • brickwork • plasterboard • concrete. [MC1]

S2.9 Position components	Determine the ideal position for the internal and external components with regard to servicing and maintenance requirements and energy efficiency: Position: • levelling • squaring. Components: • coolers • condensers • condensing units • control panels • pipe routes. [MC1, MC2]
S2.10 Insert protective materials into drilled holes	To fix protective materials into wall penetrations to prevent collapse and spread of fire: • conduits • trunking • fireproof insulation • intumescent mastic.
S2.11 Cut pipework	Cut and prepare refrigeration pipework and conduit to required dimensions, ready for connection to other components: • copper • steel • aluminium.
S2.12 Manually bend pipework	Manually bend a range of refrigeration pipes and conduits to suit the installation requirement, to include 90°, 180° and offset bends: • copper • steel • aluminium. Use hydraulic benders to bend larger diameter copper and steel pipes to the same specification as above. [MC1]
S2.13 Assemble pipework using a range of forming and jointing methods	Join refrigeration pipework and components using brazing, flaring and swaging methods: • copper to copper (Cu to Cu) • copper to iron (Cu to Fe) • copper to brass (Cu to brass) • iron to brass (Fe to brass). Forming methods: • braze (oxy-fuel) • flare • bend • swage • other mechanical joints.

	Jointing methods: • similar and dissimilar metals with hot and cold joints – mechanical and compression • copper/aluminium (Cu/Al) joints. Purging using oxygen-free nitrogen (OFN) to prevent internal scaling. Prevent components from heat damage while brazing, and the application of pipe insulation materials: • wet rag • non-conductive foam • temporary removal of low melting point items. System components: • condensing units • evaporators • condensate drains • valves • electrical cabling • drier • pressure switches • pumps • sight glass • vessels. Temperature-sensitive system components: • thermostatic expansion valves • solenoid valves • vibration eliminators • Schrader valves • pressure transducers. Fixing: • vibration damping clamps • pipe saddles • pipe clips • insulated clamps.
S2.14 Permanently fix indoor and outdoor units	Permanently fix a range of refrigeration components and supports including: • pipework • cabling • different wall, ceiling and floor materials (insulated panels, brickwork, plasterboard, concrete).
S2.15 Leak test system inert gas	Leak test a refrigeration system in accordance with the requirements of the F-Gas Regulations using inert gases prior to commissioning: • strength and tightness testing • pressure testing using inert gas • soap solutions • proprietary leak test solutions.

Outcome 3 Commission refrigeration systems (S3.1 – S3.9)	
Performance criteria	**Range and amplification**
S3.1 Interpret a risk assessment	Interpret risk assessments with consideration given to responsibilities, persons at risk and applying controls, recording potential hazards and completion of documentation. [EC4, EC5]
S3.2 Interpret information provided	Interpret regulatory, contractual and manufacturer's specifications and requirements in readiness to carry out system commissioning: • BS EN378 (Specification for refrigerating systems and heat pumps - safety and environmental requirements) • F-Gas Regulations • contractual specifications • manufacturer's instructions (including tabular and graphical information). [EC4, EC5]
S3.3 Collect data from control system	Access the system and its controls to collect a range of 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. [MC5, MC6, DC4]
S3.4 Interpret commissioning data collected	Interpret recorded data to ensure the design conditions and parameters are met: • 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. [MC6, DC4, EC5]

S3.5 Discuss requirements with stakeholders	Use open questioning and listening techniques to ensure that the end user's/client's requirements and needs are met: • product load • types of product stored • required storage temperatures • access and usage. [EC2, EC4, EC5, EC6]
S3.6 Inspect system installation	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.
S3.7 Establish a steady-state operation	Use commissioning instruments to collect and record data: • temperatures • systems pressures • flow rates • running currents. Interpret the data readings recorded to ensure that the steady-state conditions achieved meet the contractual requirements: • storage temperatures • operating pressures • superheat • subcooling • running current • air flow rates. [MC6, DC3]
S3.8 Adjust system for optimum performance	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: • storage temperature • safety controls (high and low pressure) • air flow rates • head pressure controls • position of sensors • energy efficiency. [MC6]

S3.9 Record test results	Record all commissioning data and set-points in accordance with the client's requirements, F-Gas Regulations and future reference (service activities): • 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.

Outcome 4 Maintain refrigeration systems (S4.1 – S4.11)	
Performance criteria	**Range and amplification**
S4.1 Produce a method statement	Produce a method statement and risk assessment for either preventative or reactive maintenance through interpretation of system data, customer reports or contractual requirements. Method statement: • scope of works • manufacturer's instructions • contractual requirements • risk assessment • preventative or reactive maintenance • permits to work. [EC1, EC2, EC4]
S4.2 Assess suitability of information provided	Consider all of the information available with regard to its accuracy and reliability before creating a maintenance plan: • sufficiency • accuracy • currency • previous service records • F-Gas records • customer • senses • site logs.
S4.3 Calculate resource requirements	Consider the maintenance plan and manufacturer's instructions to calculate and compile a list of all materials needed to complete the maintenance task: • refrigerant type and quantity • lubricants • cleaning agents • spare parts • consumables. [MC2, EC3]

S4.4 Produce technical reports	Complete service and maintenance site reports on work carried out and update site logs and F-Gas records. [EC3]
S4.5 Visually inspect the system	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.
S4.6 Clean system	Carry out a wide range of cleaning activities with consideration given to health and safety and maintaining maximum energy efficiency: • evaporator and condenser coils • air filters • water filters • drain pans • drain lines • unit casings.
S4.7 Extract components from the system	Remove and replace a variety of components from a refrigeration system ensuring all health and safety and environmental considerations are followed: • compressors • driers • fan motors • defrost heaters • expansion devices • refrigerants • solenoid valves • pressure control valves.
S4.8 Apply fault-finding techniques to identify faults	Apply a range of fault-finding techniques to identify a range of mechanical and electrical faults: • data analysis • observation of running conditions • review of operation logs • past service reports. [MC2, MC6, DC4, EC5]
S4.9 Rectify faults	Replace or repair a range of system faults and components to return a refrigeration system to full operational condition: • poorly fitted insulation • broken or blocked condensate drain • incorrectly set controls • component failure.

S4.10 Report on maintenance concerns	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. [EC1, EC2, EC3, EC6]
S4.11 Classify waste for disposal and recycling	Identify a range of waste materials produced during a service and maintenance activity in accordance with the current Hazardous Waste Regulations and the F-Gas Regulations: • refrigerants • lubricants • pipework • valves • driers.

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.

Guidance for delivery

There are opportunities to consolidate learning where elements of content are common across performance outcomes, for example:
- Jointing
- Charging
- Recovery.

Where content is common across installation, commissioning and maintenance activities, it is recommended 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, observation of measuring activities:
- Practical – Use of pre-set formative assessments to carry out tasks and record on standardised form. Use of a variety of measuring instruments
- Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use a 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 refrigeration classroom/workshop
- A realistic representation of refrigeration systems and components should be installed in the classroom/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 refrigeration industry
- New and emerging refrigeration technology should be included in the delivery.

Suggested learning resources

Books

- Refrigeration and Air-Conditioning (Hardcover – Illustrated) by Guy Hundy (Author)
- Refrigeration and Air Conditioning Technology (Motivate Series) by Norman Cook
- Modern Refrigeration and Air Conditioning by Althouse, Bracciano, Turnquist
- Refrigeration and Air Conditioning by A. R. Trott, T C Welch
- Air Conditioning Principles and Systems: An Energy Approach by Edward G. Pita

Websites

- www.ior.org.uk
- BSEN378:2016 standard www.shop.bsigroup.com
- www.acrib.org.uk

F-Gas:

- **Fluorinated gas (F gas) Guidance for users producers and traders**
- www.refcom.org.uk

Centres should be aware of **Annex D: Industry placement supplementary recommendations (publishing.service.gov.uk)** which includes supplementary qualifications, which will support learners knowledge of health and safety requirements in this occupation, for example, F-Gas Category 1 Certificate.

Scheme of Assessment – Refrigeration engineering

The refrigeration engineering occupational specialism is assessed by one practical assignment. The duration of the assessment is 28 hours. Learners will be assessed against the following assessment themes:

- Health and safety
- Design and planning
- Systems and components
- Inspect and test systems and components
- Report and information
- Handover and communication
- Working with faults.

Task	Typical knowledge and skills
Task 1 – Design	• Work from a specification to determine design calculations for a proposed installation. Displays a breadth of knowledge and understanding of how system, environmental and customer needs can influence design requirements.
Task 2 – Plan the installation	• Displays a breadth of knowledge and practical skills that enables them to carry out and plan for the installation of a refrigeration system. Candidates will need to produce documents to industry standards that clearly states how they will carry out the installation.
Task 3 – Install and commission the installation	• Complete the given installation and commissioning task successfully. • The task is carried out in a clear and logical sequence. • Works in a safe manner, able to carry out testing and interpret and record test results accurately • Tools, materials and equipment are selected and used correctly. • Consideration to environmental sustainability and recycling of materials. Techniques used to make building fabric repairs to restore work area to pre-installation condition. • All work carried out in line with relevant manufacturer's instructions/ building regulations.
Task 4 – Carry out maintenance activity	• Applies knowledge and practical skills in decommissioning and rectifying a fault in a component or system. • Candidates will need to be able to carry out, record and communicate maintenance activity with a customer.

The information provided in the following tables demonstrates to approved providers the weightings of each performance outcome and how each performance outcome is assessed.

Performance outcome and weighting (%)	**High level tasks** *Provide specific instructions for candidates to provide evidence for and are the same for every version of the assessment*	**Assessment Theme**	**Typical evidence**
PO2 Install refrigeration systems (37%)	T1– Design T2 – Planning the installation	Health and Safety	Risk assessments, PPE, Working safely
	T2- Planning the installation	Design and Planning	Method statements, installation diagrams, material lists, Selecting types of systems and components, design calculations
	T3 – Install and commission	Systems and components	Using tools and equipment, cutting and bending pipe, jointing methods, prefabrication of pipe, positioning and securing components
	T1– Design T3 – Install and commission	Reports and information	Interpretation of drawings, specifications, and manufacturer instructions

PO3 Commission refrigeration systems (23%)	Task 3 – Install and commission	Inspecting and testing systems and components	Pressure testing, testing for leaks, commissioning checks
	T3 – Install and commission	Health and Safety	Risk assessment, working safely, PPE
	T3 – Install and commission	Reports and information	Commissioning records
	T3 – Install and commission	Handover/ communication	Handover to customer
	T4 – Carry out service and maintenance		
PO4 Maintain refrigeration systems (40%)	T4 – Carry out service and maintenance	Health and safety Working with faults Handover/ communication Reports and information	Risk assessment, working safely, PPE Fault diagnosis, client requirements, Repair and replace components, use of tools Communication with customer to diagnose fault Maintenance activity report

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