T Level Technical Qualification in Building Services Engineering for Construction

Specification

First teaching from September 2022
Version 1.4

Qualification at a glance

T Level route	Construction
T Level pathway	Building Services Engineering
City & Guilds number	8710
Age group approved	16-19
Entry requirements	Formal entry requirements are not set by City & Guilds. However, it is expected that Learners have the appropriate attainment at Level 2 before commencing their studies.
Assessment	Core - knowledge tests are externally assessed Core – employer-set project is externally assessed Occupational specialisms are externally moderated
First registration	September 2021

Title and level	City & Guilds number	Qualification number (QN)
T Level Technical Qualification in Building Services Engineering for Construction	8710	603/6911/5

Version and date	Change detail	Section
1.1 Feb 2021	Updated age ranges	Qualification at a glance
	Assessment dates updated in availability of assessments	Scheme of Assessment
	Provider and Technical Qualification approval criteria	Centre requirements
	Update qualification title	What is this qualification about
	Transfer of attainment added	Delivering the technical qualification
1.2 May 2022	How does the technical qualification work within the T Level?	What is this qualification about Pg 8
	Requirements of the T Level	T Level Structure Pg 12
	Approval information	Centre Requirements Pg 15
	Definition of threshold competence	Technical qualification grading and result reporting Pg 46
	Contribution of occupational specialism grade when two occupational specialisms are taken	Technical qualification grading and result reporting – T Level Grading Pg 47
	Sources of general information updated for currency	Appendix 1: Sources of general information Pg 403
	Additional contact details added	Get in Touch Pg 406
1.3 Jul 2023	Alignment of text in relation to ESP Assessment Objective (AO3) with assessment materials	Core Component Scheme of assessment Pg 33
	Centre staffing requirement wording	Resource requirements - Centre staffing Pg 16
	Transfer of attainment section updated	Delivering the technical qualification Pg 21
	Permitted assessment materials for Core exams added	Core component scheme of assessment Pg 31
	Amendments to terminology in assessment availability table	Availability of assessments Pg 41
	Core grading table inserted	Core grading Pg 36
	T Level grading table	T Level grading Pg 48
1.4 Jul 2023	List of physical resources expanded	Physical resources Pg 18

We would like to take this opportunity to thank all the employers, trade associations, professional bodies, providers, subject matter experts and consultants who have worked tirelessly alongside us on the development of the TQ. A special thank you to our Employer Industry Board who have dedicated time to review and validate the specifications and TQ documentation. This collaborative work is to ensure that a student studying the Building Services Engineering T level has the best opportunities available to them as they progress through their career with a solid base as a starting point.

- Balfour Beatty
- Barlows Electrical
- Blueflame Associates
- CIPHE
- Convections
- Corgi Technical Services
- Daikin UK
- Electrical Services & Projects Ltd
- Elekta
- Energy Rating Services
- Engineering Forensics
- F-Cold
- Heat Engineer Software Ltd
- Herts Cooling Ltd
- Hoare Lee / CIBSE Representative
- Interserve
- MG Plumber
- National Grid
- NET (National Electrotechnical Training)
- NG Bailey
- Paddeco
- Partner Troup Bywaters
- Pitkin & Ruddock Ltd
- Salamander Pumps
- Stanley Products and Solutions
- TGB Mechanical Services

The Outline Content for the T Level Technical Qualification Building Services Engineering for Construction has been produced by T Level panels of employers, professional bodies based on the same standards as those used for Apprenticeships. The outline content can be found on the institute website: **https://www.instituteforapprenticeships.org/t-levels/approved-t-level-technical-qualifications-and-final-outline-content/**

City & Guilds has amplified the Outline Content to create the Technical Qualification specifications.

Contents

1 Introduction

What is this qualification about?

The following purpose statement relates to the **T Level Technical Qualification in Building Services Engineering for Construction.**

Area	Description
OVERVIEW	
What is a T Level?	T Levels are new courses which will follow GCSEs and will be equivalent to three A Levels. These two-year courses have been developed in collaboration with employers and businesses so that the content meets the needs of industry and prepares learners for work. T levels are one of three post 16 options for young people which are: • A Levels • Apprenticeships • T Level
How does the Technical Qualification work within the T Level?	This Technical Qualification specification contains all the required information you need to deliver the qualification in the T Level in Construction: Building Services Engineering. The Technical Qualification forms a significant part of the T Level in Construction: Building Services Engineering (BSE). City & Guilds are responsible for the development and ongoing operational delivery of this Technical Qualification. All other parts of the T Level as listed below will need to be achieved by a Learner for the Department for Education to award the successful completion of this T Level. It is important to note that City & Guilds do not have responsibility of delivery for the other parts of the T Level but will continue to support centres where they can on all aspects of T Level delivery. Additional mandatory parts of the T Level that need to be achieved: • A 315-hour minimum industry placement.
Who is this qualification for?	This qualification is for you if you are a 16-19-year-old learner, who wishes to work within the Building Services Engineering Industry. It has been designed to deliver a high level of knowledge about the BSE industry as well as the occupational skills required to enter the industry (known as 'threshold competence'). A learner who completes this qualification is

	well placed to develop to full occupational competence with the correct support and training.
What does this qualification cover?	The qualification will help you gain an understanding of the BSE industry and the sector and you will cover topics such as: Health and Safety, construction science principles, sustainability in the construction industry and building services engineering systems. A learner will have the choice of studying one standalone occupational specialism or a combination of specialisms as listed below. Standalone: • Electrotechnical engineering • Electrical and electronic equipment engineering • Protection systems engineering • Gas engineering Combinations: • Plumbing engineering and Heating engineering • Heating engineering and Ventilation • Air conditioning engineering and Refrigeration engineering Centres and providers work with local employers who will contribute to the knowledge and delivery of training. Employers will provide demonstrations and talks on the industry and where possible work placements will also be provided by the employers.

WHAT COULD THIS QUALIFICATION LEAD TO?	
Will the qualification lead to employment, and if so, in which job role and at what level?	This qualification focuses on the development of knowledge and skills needed for working in the BSE industry, which will prepare learners to enter the industry through employment or as an Apprentice. Furthermore, the completion of this qualification gives the learner the opportunity to progress onto higher education courses and training.
Why choose this qualification?	This qualification will suit someone who is not yet employed or looking to enter the industry post mainstream education. The structure of the qualification is designed to give learners the breadth of knowledge and understanding across the BSE industry but also equips them with necessary occupational and core skills to enter the industry. This qualification is designed to support fair access and allows learners to manage and improve their own performance.
WHO SUPPORTS THIS QUALIFICATION?	
Employer route panels	The content of this qualification is outlined by a representative panel of employers from across the industry sector. It therefore prescribes the minimum knowledge and skills required to enter the industry. The content in this specification is approved by the Institute for Apprenticeships and Technical Education.

Key information

Below is a summary of the key information provided to centres to support delivery of this technical qualification.

Guided learning hour (GLH) value

Values for GLH are calculated by considering the duration needed for the activities that a typical learner would need to complete to be able to demonstrate the knowledge and skills across the qualification content. This includes contact with tutors, trainers or facilitators as part of the learning process, and includes formal learning such as classes, training sessions, coaching, seminars and tutorials. This value also includes the time taken to prepare for, and complete, the assessments for the TQ qualification.

Centres should be aware that when planning programmes of study around the GLH that the GLH is based on a typical learner for this qualification. However, learners progress and develop at a different pace that is unique to the individual learner, and learners will have different qualification relevant experience. To accommodate this centres must be aware that some learners will not need the full GLH to develop and demonstrate the required knowledge and skills and some learners will need slightly longer than the proposed GLH to develop and demonstrate the knowledge and skills required. Therefore, centres should plan the flexibility within their programmes of study to reflect and support the needs of all learners.

Total Qualification Time (TQT) value

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

Criteria

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

What do learners need to learn?

The primary purpose of these sections is to support the delivery of the content in the criteria. These sections provide context in relation to the depth and breadth to which a subject or topic needs to be taught.

Skills

This section provides a mapping reference to the core, maths, English and digital skills that are embedded within the technical qualification content.

Example

3.3 Role of different **disciplines** involved in design.

Range:

Disciplines - Contractors and all operatives, architects and all professional occupations, planners and building inspectors, manufacturers

What do learners need to learn?

A basic knowledge of key job roles within construction design including the responsibilities and reporting lines/lines of escalation within roles. The key activities aligned to the disciplines with an appreciation of potential career progression routes.

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 have to successfully complete an industry placement and any other requirements set by the Institute for Apprenticeships and Technical Education such as licence 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 FGas 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. Threshold competence is defined as when a learner’s attainment against the knowledge, skills and behaviours is of a standard for them to enter the occupation and industry. They must also demonstrate the ability to achieve occupational competence over time with the correct support and training.

To achieve the **T Level Technical Qualification in Building Services Engineering for Construction** learners must complete the two components of the Technical qualification. These are known as the core component and the occupational specialism:

- Building services engineering core component (350)
- Plus, **two** occupational specialism components that **must** be (351 & 358) or (355 & 359) or (356 & 355) or **one** occupational specialism component that must be (353) or (354) or (357) or (352).
- Learners must be registered on the mandatory POS and one other POS covering the occupational specialisms.

T Level Technical Qualification for Building Services Engineering in Construction

Programme of study (POS)	**City & Guilds component number**	**Component title**	**Component level**	**GLH**	**TQT**
Mandatory					
8710-30	350	Building services engineering core content	Level 3	520	650
Choose one standalone occupational specialism or one combination of occupational specialisms.					
Standalone					
8710-33	353	Electrotechnical engineering	Level 3	650	820
8710-32	352	Electrical and electronic equipment engineering	Level 3	570	740
8710-37	357	Protection systems engineering	Level 3	570	720
8710-34	354	Gas engineering	Level 3	650	735
Combinations					
8710-36	356 355	Plumbing engineering & Heating engineering	Level 3	840	975
8710-35	355 359	Heating engineering & Ventilation	Level 3	765	880
8710-38	351	Air conditioning engineering	Level 3	700	850

	358	& Refrigeration engineering	

2 Centre requirements

Approval

All eligible providers must obtain Full Provider Approval with City & Guilds prior to delivering any T Level Technical Qualification (TQ).

Provider approval is not equivalent to centre approval; any provider which is already an existing City & Guilds approved centre must still obtain Full Provider Approval in the first instance. There is no fast-track approval for these qualifications.

Once successfully approved, providers can apply for additional TQs or apply to add additional occupational specialisms (OS) during each approval window.

The approval application consists of a comprehensive set of approval criteria agreed with the Institute to ensure an eligible provider is fit and ready to deliver T Level Technical Qualifications.

These criteria seek to ensure the integrity of the qualifications for both City & Guilds and the Institute. They must be adhered to throughout the delivery of the TQ and will be reviewed at the annual self-assessment.

Criteria A	Management Systems
Criteria B	Industry placement
Criteria C	Resources
Criteria D	Delivery
Criteria E	Assessment and standardisation plan
Criteria F	Secure live assessment and administration
Criteria G	Conflicts of Interest (COI)

Please refer to our published provider approval and quality assurance information document available on our website **here**. This document includes information around the approval process, criteria for approval and the timeline for the relevant academic year.

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.

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 or be working towards this level of qualification
- 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 L3 Construction/BSE qualifications will be able to teach the core subjects.

Occupational specialisms specific requirements

Electrotechnical engineering

Hold an NVQ level 3 in Electrical Installations or equivalent qualification and have an AM2 qualification **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 L3 in Electronic Security and Emergency systems or a suitable L3 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.

Electrical and electronic equipment engineering
Hold an NVQ L3 or equivalent in Electrical and Electronic engineering or equivalent qualification and relevant CPD that demonstrates experience of working with the range of 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.

Heating and ventilation
Hold an NVQ level 3 in Heating and ventilation 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.

Staff assessing these qualifications must meet the above requirements 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

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 carried out to mitigate
- At least one clean copy of the current version of the following, per test rig: BS:7671, IET Onsite Guide and IET Guidance Note 3

Electrical and electronic equipment

- **Hand tools:** rules, levels, cable cutters, screwdrivers, wire strippers, knives, wrenches, hammers, saws, data cabling crimps, insulation displacement tools
- **Power tools:** hammer drills, electric screwdrivers, soldering irons
- **Testing equipment:** digital multimeters multi-function installation test equipment, network LAN test equipment, proving units, Approved voltage indicators, safe isolation locking kits, Portable Appliance tester (PAT), anti-static (grounding lead) kits, anti-static wristbands, anti-static bench top mats
- **Reference materials:** at least one clean copy of the current version of the following: IET Code of Practice for In-service inspection and testing of Electronic Equipment [IETCOPISITEE], IET CoP Building Integration and Control Systems, IET CoP Connected Systems Integration in Buildings, BS 7671 and the IET On-site Guide
- **Appliances/hardware:** PCs, laptops and tablets (Android or iOS) for setting up app-based equipment for setting up app-based equipment, Class III appliance (such as an electric heater), a range of Class II appliances (such as a monitor), a range of Class I appliances (such as a telephone with ELV transformer supply), sound system amplifier (minimum two channel input), microphone, speaker (wired), smart speaker (wireless), broadband routers with Wi-Fi capability and internet connection, patch cabinets, routers, network switches, point of sales, display screens for point of sales, smart equipment (e.g. Hive), HDMI-enabled monitors/TVs
- **Software**: samples of software/firmware/drivers and apps for BMS systems, antivirus software, heating system controls, lighting system controls, network systems, Wi-Fi extenders

Protection systems engineering

- 230 V AC voltage indicator and proving unit
- 230 V AC mains isolation and lock-off kit
- Digital multimeter (DMM)
- RJ-45 crimping tool
- RJ-45 Krone tool

- CAT5e/CAT6e cable tester
- BNC crimp tool
- RJ-45 connectors; wall sockets/plugs
- RG-59 BNC crimp connectors
- Range of cables – 8-core 0.22 mm^2 alarm, FP200, RG-59 co-axial, CAT5e

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

Plumbing engineering

- **General plumbing tools**: screwdrivers, power drills, hammers, chisels, grips, wrenches, adjustable spanners, spirit levels, manual pipe threaders, pipe cutters (low-carbon steel, plastic and copper), hand saws, pliers, circlip pliers, plungers, tap reseating tools, drain augers, drain rods, pressure gauges, flow cups, thermometers, bending tools, blowtorches
- Electrical safe isolation kits
- **Specialist plumbing tools**: hydraulic machine benders, hydraulic crimping kits, hydraulic pressure testers
- **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
- **Commissioning equipment**: cold water, hot water, sanitation, rainwater
- Suitable access equipment for the location
- PPE
- **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 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)

- Building information management software to allow updating of basic data as part of a planning review
- Appropriate waste disposal and recycling facilities

Heating engineering

- **General heating tools:** screwdrivers, power drills, hammers, chisels, grips, wrenches, adjustable spanners, spirit levels, manual pipe threaders, pipe cutters (low-carbon steel, plastic and copper), hand saws, pliers, pressure gauges, flow cups, thermometers, bending tools, blowtorches (soldering equipment, pipe benders, adjustable spanners, etc)
- **Suitable boilers:** Electric boilers or gas boilers that have been pre-installed and checked by a competent member of staff (tightness/flue/operation). Where gas boiler is used suitable extraction must be available
- **Specialist heating tools:** hydraulic machine benders, hydraulic crimping kits, hydraulic pressure testers, circular saws, jig saws, reciprocating saws, portable pipe freezing kits
- Electrical safe isolation kits
- Suitable access equipment for the location
- **Measuring equipment:** (tape measures, digital measuring equipment)
- **Commissioning equipment:** central heating
- PPE
- **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, expansional 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 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
- 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 chamber/burner seals, gas seals, water seals, thermistors, air/gas ratio control valves, 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,

Ventilation

- **General ventilation tools**: metal snips, grinders, cordless drills/drivers, selection of suitable screwdrivers, selection of adjustable spanners, open and box spanners, hacksaws
- **Specialist ventilation equipment**: anemometers (rotating vine or hot-wire), flow meters temperature sensors, bolometers
- **Measuring equipment**: tape measures, laser measures, spirit levels
- PPE
- Electrical safe isolation kits.
- Suitable access equipment for the location, including mobile tower scaffolds.
- Vacuum cleaners
- **Ventilation systems:** mechanical ventilation, mixed mode ventilation, mechanical ventilation with heat recovery (MVHR), supply, extract, local exhaust ventilation (LEV), kitchen extract, fire and smoke
- **Ventilation components:** fans, volume control dampers, fire dampers, silencers, diffusers, inlet and extract grilles, range of filters, heating and cooling coils, air handling

units (AHUs), fan coil units (FCUs), air-to-air heat exchangers, variable air volume (VAV) boxes, time clocks, isolators

- **Electrotechnical components:** inverters, actuators, sensors, motors thermostats, humidistats, anemometers, manometers
- The installation area must contain a pre-installed 13 A electrical supply (including emergency stop button provision)
- Building information management software to allow updating of basic data as part of a planning review
- Appropriate waste disposal and recycling facilities

Internal quality assurance

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

Learner entry requirements

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

Formal entry requirements are not set by City & Guilds, 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

3 Delivering the technical 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.

City & Guilds 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.

Programme delivery

The technical qualification should be delivered through approaches that meet the needs of learners. City & Guilds 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 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.

4. 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 on to 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 on to 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 digital 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

5 Scheme of Assessment

Assessment methods

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. 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 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

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

Or

One occupational specialism from (353) or (354) or (357) or (352)

These assessments will feature a considerable practical element and are composed of a series of holistic practical tasks relating to the specialism at hand. They will take place over a period of time, scheduled at the 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.

Grading and marking

The building services engineering core (component 350) is graded overall A*–E plus ungraded (U).

The occupational specialisms (components 351–359) are graded overall Distinction, Merit, Pass and Ungraded. Each occupational specialism achieved will receive a grade.*

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

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 (031)	Externally set exam	2.5 hours	110	35%	Externally marked	This component will be awarded on the grade scale A* - E
Exam paper 2 (032)	Externally set exam	2.5 hours	110	35%	Externally marked	
Employer-set project (033)	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 (353)	Externally set assignment	24 hours	90	100%	Externally moderated	All occupational specialism components will be awarded on the grade scale P, M, D
Electrical and electronic equipment (352)	Externally set assignment	16 hours	90	100%	Externally moderated	
Protection systems engineering (357)	Externally set assignment	15 hours	90	100%	Externally moderated	
Gas engineering (354)	Externally set assignment	24 hours	90	100%	Externally moderated	

Occupational Specialism Component* – Learners must complete both assessment components from one of the combinations below						
Assessment component	**Method**	**Duration**	**Marks**	**Weighting**	**Marking**	**Grading**
Plumbing and Heating engineering						
Plumbing engineering (356)	Externally set assignment	21 hours	90	100%	Externally moderated	All occupational specialism components will be awarded on the grade scale P, M, D
Heating engineering (355)	Externally set assignment	20 hours	90	100%	Externally moderated	
Heating engineering and Ventilation						
Ventilation (359)	Externally set assignment	20 hours	90	100%	Externally moderated	All occupational specialism components will be awarded on the grade scale P, M, D
Heating engineering (355)	Externally set assignment	20 hours	90	100%	Externally moderated	
Air conditioning and Refrigeration engineering						
Air conditioning engineering (351)	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 (358)	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 City & Guilds. 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. The level of difficulty 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 A copy of the IET Wiring Regulation BS7671

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. The level of difficulty 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 A copy of the IET Wiring Regulation BS7671

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 is **externally set and externally marked** by City & Guilds 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 whole of the BSE core content. Projects will be released to centre staff in advance of any of the assessment windows for each task. City & Guilds will provide centres with assessment windows for centres 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 learned 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	City & Guilds sets the assessment window for the centre to timetable	3 hours
1.2	City & Guilds sets the assessment window for the centre to timetable	6 hours
1.3	City & Guilds sets the assessment window for the centre to timetable	3 hours
1.4	City & Guilds sets the assessment window for the centre to timetable	2.5 hours
2.1	City & Guilds sets the assessment window for the centre to timetable	1.5 hours
2.2	City & Guilds 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, and 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. Once learner evidence has been marked, Internal Assessors will make a holistic judgement on performance by applying the knowledge and skills that have been demonstrated to assessment themes within the marking grid.

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 assignment 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. Assignments will be released to centre staff towards the end of the learners' programme, usually the week before Easter each year. Centres will be required to maintain the security of all live assessment materials until assessment windows are open. Assignments will therefore be password-protected and released to centres through a secure method. Guidance on equipment, resources and duration will be released as appropriate to ensure centres can plan for delivery of practical assignments in advance. The marking grid for the assignment will be available to centres from the start of the learning programme. 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 assignments City & Guilds provides guidance and support to centres on the marking process and associated marking grid in the assessment pack for the qualification, and guidance on the use of marking grids.
Electrical 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
Electrical and electronic equipment	Externally set, externally moderated	**Content overview** Learners will be able to: • Install electrical and electronic equipment systems • Commission electrical and electronic equipment systems • Maintain electrical and electronic equipment systems • Decommission electrical and electronic equipment 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 engineering	Externally set, externally moderated	**Content overview** Learners will be able to: • Install plumbing systems • Commission plumbing systems • Maintain plumbing systems • Decommission plumbing 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

Heating engineering	Externally set, externally moderated	**Content overview** Learners will be able to: • Install heating systems • Commission heating systems • Maintain heating systems • Decommission 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
Ventilation	Externally set, externally moderated	**Content overview** Learners will be able to: • Install ventilation systems • Maintain ventilation systems • Commission ventilation 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	Written exam	June	Set date/time
	*Autumn series	Written exam	November	Set date/time
Core exam 2	Summer series	Written exam	June	Set date
	*Autumn series	Written exam	November	Set date
Employer-set project	Summer series	Project	April - May	Assessment window
	*Autumn series	Project	October-November	Assessment window
Occupational specialism	One series annually	Assignment	February – May (first assessment 2023	Assessment window

*Please note that the retake series is not only restricted to retakes.

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

Calculating the grade of the core component uses the aggregation of points from across all assessment components in the core to calculate the overall grade for the core component.

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 City & Guilds 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 City & Guilds 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 qualification grade for the T Level in Building Services Engineering for Construction. The calculation of the qualification grade will be based on performance in the core component and occupational specialism, as set out below.

Calculation of the T Level Qualification 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

Note, for the Technical Qualification in BSE for Construction, the overall T Level Qualification Grade has a contribution from each component as outlined in the table below.

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

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

Malpractice

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

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

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

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

Where suspected malpractice is identified by a centre after the candidate has signed the declaration of authentication, the Head of Centre must submit full details of the case to City & Guilds at the earliest opportunity. Please refer to the form in the document *Managing cases of suspected malpractice in examinations and assessments*.

Accessibility

In the design of the technical qualification and its assessments the following principles have been applied:

- In the development of content, tasks and assessments, **all** learners are considered.
- Materials are well designed and do not create barriers to attainment. This includes content being presented logically and in an uncluttered way.
- No particular characteristics or groups of learners are disadvantaged by features of the qualification.
- Language is appropriate and presented in its simplest form to provide fair access to all learners.
- In the design of content and assessments, the impact on learners' social, behavioural and emotional wellbeing is considered.
- Physical and sensory needs of learners in accessing content and assessments are considered

Access arrangements

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

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

Please refer to the *JCQ access arrangements and reasonable adjustments and Access arrangements - when and how applications need to be made to City & Guilds* for more information. Both are available on the City & Guilds website: **http://www.cityandguilds.com/delivering-our-qualifications/centre-development/centre-document-library/policies-and-procedures/access-arrangements-reasonable-adjustments**

Special consideration

City & Guilds can give special consideration to candidates who have had a temporary illness, injury or indisposition at the time of the examination. Where City & Guilds does this, it is given after the examination.

Applications for either access arrangements or special consideration should be submitted to City & Guilds by the Examinations Officer at the centre. For more information please consult the current version of the JCQ document, *A guide to the special consideration process*. This document is available on the City & Guilds website: **http://www.cityandguilds.com/delivering-our-qualifications/centre-development/centre-document-library/policies-and-procedures/access-arrangements-reasonable-adjustments**

Informing candidate of pre-moderated marks

Centres are required to inform candidates of their marks **before** external moderation. It is important that candidates are informed of their pre-moderated marks are provisional and allow sufficient time for them to appeal if felt necessary while still allowing their agreed centre marked work to be available for external moderation on time.

Centres must also provide candidates with a copy of their marked work and the centre's internal appeals procedures on request.

Internal appeals procedure

For internally marked assessments, all centres must have an internal appeals procedure for candidates, which gives them the opportunity to appeal the centre mark for their work, before moderation takes place. The procedure must ensure:

- the person completing the appeal is competent and did not mark the work originally
- that any marking errors are identified and corrected
- the candidate is informed of the outcome, reason and any change in mark.

The City & Guilds appeals process also covers access arrangements, special consideration, and malpractice. Applications are not accepted directly from candidates, but the centre can apply on a candidate's behalf. Where relevant, centres must tell candidates how to request this. The centre can refuse to make the application to City & Guilds, but the candidate must be given the opportunity to appeal this decision. This information must be included in the centre's internal appeals procedure.

Centres must provide candidates and City & Guilds with a copy of their internal appeals procedure, on request.

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

The services available include a review of marking and review of moderation. Requests must be submitted within the specified period after the publication of results for individual assessments.

For further details of enquiries about results services, please visit the City & Guilds website at **www.cityandguilds.com.**

8 Components

Content of components

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

- City & Guilds reference number
- Title
- Level
- Guided learning hours (provisional)
- Assessment method
- Introduction section
- Underpinning knowledge outcome – including range and depth sections
- What learners need to learn
- Links to maths, English and digital skills
- Guidance for delivery
- Suggested learning resources
- Scheme of Assessment*

*Occupational specialisms only

350 Building Services Engineering Core

Level:	3
GLH:	520
Assessment method:	Two Knowledge tests Employer-set project

What is the component about?

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

- Fundamental Health 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.

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 engineers perform?
- What systems do Building Service Engineers work on?
- What tools and equipment building service engineers use as part of their role?

Underpinning knowledge outcomes

On completion of the BSE Core, learners will understand

1. Health and safety 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

Completion of the Building Services Engineering core will give learners the opportunity to develop their maths, English and digital skills. Details are presented in the skills section of each criterion.

BSE Core content

1. Health and safety in construction

Criteria

1.1 Construction **legislation and regulations**

Range:

Legislation and regulations - Health and Safety at Work Act (HASAWA), Reporting Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR), Control of Substances Hazardous to Health (COSHH), 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, environmental 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.

What do learners need to learn?	Skills
The role of legislation and regulations in the construction industry, including the role of the Health and Safety Executive (HSE). How current legislation impacts employer, employee and construction projects within a domestic and commercial setting. Regulations relating to provisions of welfare facilities during construction work (toilets, washing facilities, drinking water, heating, changing rooms and lockers, rest facilities etc). How to access to information related to welfare responsibilities Onsite. The bodies responsible for maintaining and updating legislation and regulations. The implications of not adhering to the legislation on the public, client, business and employers and employees including enforcements, penalties, and imprisonment. The difference between statutory and non-statutory documents, where each document is applicable in terms of construction activities. Regulations and the overarching guidance documents for working in the building services engineering sector including the activities and procedures they cover.	CSB EC5

1.2 Public liability and employer's liability

What do learners need to learn?	Skills
What liability is and what the current requirements are relating to public and employer liability for construction employees and employers. The implications of public liability such as, injury, illness/death, legal action and compensation, and employer's liability such as employee and public injury, accidents, compensation, medical cost, legal costs and loss of income.	EC5

1.3 Approved construction codes of practice

What do learners need to learn?	Skills
Where to obtain approved codes of practice through the HSE L series publications. Their use, purpose and legal status and how these are applied in the construction industry.	EC5

1.4 Development of **safe systems of work**

Range:
Safe systems of work - Company management systems, risk assessments, method statements, permits to work, safety notices and CSCS cards.

What do learners need to learn?	Skills
How safe systems of work are developed and used in construction projects. Roles and responsibilities, recording and reviewing and any potential implications of not having systems in place. How to write method statements, How to complete risk assessments How to complete a COSHH assessment How to apply CDM Site signage requirements Construction Skills certification scheme (CSCS) (SMSTS) (SSSTS)	EC3 EC5

1.5 **Safety conscious procedures**

Range:

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

What do learners need to learn?	**Skills**
Procedures that aim to promote and support safety consciousness within construction sites/environments/workshop areas. The benefits of having these procedures in place and the potential implications of not adhering to them – (i.e. injury/death, loss of business, fines, increased costs, project timescales slipping etc.)	EC1 EC3

1.6 **Safety inspection** of a work environment

Range:

Safety inspection - sensory inspections, visual inspections, recording documents.

What do learners need to learn?	**Skills**
The methods used to inspect a workplace to ensure it is safe for work. Review of area/site/workshop, use of guidance and HSE regulations, documentation used to define safe methods, dimensions, ratios and mitigate potential risks and technical health and safety terms used in the construction industry. Types and use of recording documentation • Register of inspection • Access equipment • Work equipment	CSA CSC EC3 MC4

1.7 **Implications** to those working within the BSE industry of not following health and safety legislation

Range:
Implications - penalties, improvement notice, prohibition notice, powers of prosecution.

What do learners need to learn?
Roles and responsibilities and the consequences of not carrying out own role and responsibilities for those working within the BSE industry i.e. • Employer • Employee • General Public • Health and Safety Executive

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

Range:
Systems - Water supplies, gas supplies, electrical supplies.

What do learners need to learn?	Skills
The methods used to safely isolate various services/ 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.	CSC MC10

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

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

What do learners need to learn?	Skills
The consequences of not working safely on site to individual stakeholders. The implications of poor health and safety and who these impacts at different levels i.e. employee, employer/business, client/customer/public.	MC2

1.10 **Recording and reporting** of safety incidents and near misses.

Range:

Recording and reporting - accident book, reporting procedure, accident and incident reporting policy, RIDDOR reportable incidents.

What do learners need to learn?	Skills
The correct process to undertake and follow when reporting an incident or near miss in the workplace.	CSA CSD EC3

1.11 **Emergency procedures** for **unsafe situations**

Range:

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

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

What do learners need to learn?	Skills
The correct procedures to follow if unsafe situations occur in the workplace. Actions to be taken when dealing with fire situations. The different fire extinguisher and their use.	CSC EC5

1.12 **Types of PPE**

Range:

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

What do learners need to learn?
The purpose and correct use of appropriate PPE to mitigate risks.

1.13 First aid facilities

What do learners need to learn?

The first aid facilities that must be available in the work area in accordance with Health and Safety regulations.

1.14 Warning signs for the seven main groups of hazardous substance

What do learners need to learn?

The categories of safety signs.

The symbols for hazardous waste.

The meaning of each pictogram in the CLP Regulation and where they would be encountered.

1.15 Safe practices and procedures for the use of **access equipment and manual handling**

Range:

Access equipment - ladders, mobile scaffold towers, platforms, trestles, steps, podiums, staging, boom and scissor lifts.

Manual handling – single, two-person lift, mechanical lifting aids.

What do learners need to learn?	**Skills**
The different types of access equipment and manual handling operations. The safety checks to be carried out on access equipment; visual, tagging, fit for purpose, secure level ground, operative’s competency for use of equipment. Safe erection methods for access equipment. 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. Ratios and advantage of pulleys and other lifting aids.	MC4

1.16 Safe practices and procedures for working in excavations and confined spaces

What do learners need to learn?

- Safe working in excavations.
- The safety measures when working in excavations.
- The dangers associated with excavations.
- Safe working in confined spaces.
- The dangers associated with confined spaces.
- The safety measures used when working in confined spaces.

2. Construction science principles

Criteria

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

Range:

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

What do learners need to learn?	**Skills**
The Internationally recognised (SI) units of measurement and their application and use in building services engineering calculations including multiples and sub-multiples. Use of SI units and derived multiples in calculations.	MC1

2.2 **Derived SI units**

Range:

Derived SI units - area (m^2), volume (m^3), flow (l/s and m^3/h), density (kg/m^3), velocity (m/s), specific heat capacity (kJ/kg/°C), acceleration (m/s^2), volt, ampere, ohm.

What do learners need to learn?	**Skills**
All derived SI units and their application and use in building services engineering including those associated with area, volume, weight, power, energy and force. Use of SI units and derived multiples in calculations.	MC2

2.3 **Materials** science **principles**

Range:

Materials – pure metals, ferrous metals, alloys/solders, plastics (thermosetting and thermoplastic), fireclays/ceramics, natural and synthetic rubbers.

Principles - material properties, chemical composition, degradation, failure, effects of environmental conditions, ductility, malleability, conductivity, tensile strength, compressive, strength, durability.

What do learners need to learn?	Skills
The principles of material science in construction design and how buildings will perform in terms of durability and stability. Properties of materials, their uses and the reasons that they are suitable for application. Methods of material testing. Environmental conditions: 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.	CSB MC4

2.4 **Mechanical science principles**

Range:

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

What do learners need to learn?	Skills
Key principles of mechanical science and how they are used to inform construction methods and the relationship between force, work, energy, power and efficiency. Calculations for all mechanical principles in range. Basic mechanics: theory of moments, action and reaction, centre of gravity, equilibrium, velocity and ratio, mechanical advantage. Simple mechanics: levers, pulleys, Archimedes, screw.	MC4

2.5 **Electricity principles**

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

Electricity principles in relation to the construction process and use of the completed building:	**Skills**
• Types of electricity sources (including fossil fuel, nuclear and renewable energy) • The types of power plants used to provide reliable sources of energy (including coal, oil, gas and nuclear). • Transformation (electromagnetic induction and types of transformers (step up and down, three phase, single phase)). • Distribution (via networks to industry and domestic users). • Voltage currents and resistance and the relationship with power, energy and efficiency. Calculations used, including Ohms law. Why different equipment requires a different voltage, 12 V, 110 V, 230 V, 400 V.	
Circuit protection devices: Residual Current Devices (RCD)	
The various uses of electricity within the built environment including basic DC circuit principles, Ohm’s law and relationships between circuit values. Units of electrical measurement • Ohm’s law • power consumption of electrical circuits • basic over-current protection device size • voltage, current and resistance in series and parallel circuits • current (amps) • voltage (volts) • resistance (ohms) • power (watts) **Electrical principles and simple calculations** **Basic principles:** • measurements of electrical flow • material conductivity, resistivity and resistance • direct and alternating current • earthing requirements for systems	MC4

2.6 **Structural science principles**

Range:

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

What do learners need to learn?	Skills
Structural science principles its use and effects and how it informs the construction and design of buildings. • The effects of forces on materials and building: compression and torsion stress, tension, bending, and shear • The different types of loads acting on structures: vertical, horizontal and longitudinal • Material properties: strength, malleability, hardness, elasticity • Different types of structural members: footings, walls, beams, roof trusses, columns and beams. • Compliance with document • Calculations: permitted notching zones and maximum depths of holes and notches • Drilling and notching conventions • Importance of calculations being conducted in structural design: beam, load, column. • Appreciate the effects of adjacent structures, trees, drains and sewers, ground conditions, on the design of foundations • Where to find the Building Regulations that cover foundations	CSB MC4 DC4

2.7 **Heat principles**

Range:

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

What do learners need to learn?	Skills
Key principles of heat transfer and its cause and effect within the built environment. • Heat transfer: conduction, convection and radiation and how they are managed to lessen the environmental impact. • Characteristics of air: temperature, density and humidity • Condensation: sources, types and effects of condensation and controls • Thermal conductivity: R and U values • What impacts heat loss in a building: building fabric, ventilation and air temperature • Calculations: thermal conductivity, resistance, heat loss, conduction and convection • Effects of thermal expansion • How buildings are affected by temperature change, (design, faults) • How condensation is created, and buildings are designed to overcome this. • Effects of moisture on construction materials, • Methods of generating power within a building: solar, photovoltaic, heat recovery, gas, electric • Methods of heating / cooling buildings • Heat Loss calculations: Resistance - $R = {}^{T}/_{K}$, Heat Loss – $Q=UA (T1-T2)$ • Thermal expansion calculations: change in length = coefficient of thermal expansion x change in temperature x original length • Space heating calculations: specific heat capacities	MC4

2.8 **Light principles**

Range:

Light principles - refraction, difference in artificial and natural light, glare, directed and reflected light, flow of light energy, daylight factor, colour rendering, Efficacy (lumens/watt).

What do learners need to learn?	Skills
How artificial and natural light are incorporated into the design of a building considering energy use and pleasant environment for the end user. Methods used to diffuse light. Calculate efficacy of lamps and luminaires.	MC4

2.9 **Acoustics principles**

What do learners need to learn?	Skills
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. Factors that affect acoustics of types of buildings including frequencies, reverberation, reverberation time, decibels, focusing, resonance, and echo. Acoustic principles in action in the construction industry • insulation • sound absorption • use of specific acoustic materials The effect on the operative and upon the wider environment through noise pollution, and external sources of sound and noise. Use of decibels: as a unit of measure, additional levels, and threshold limits. Compliance with approved document E (resistance to sound).	MC4

2.10 **Earth science principles**

Range:

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

What do learners need to learn?
Earth science principles and how these impact the built environment and basic construction design principles. Physical geography including land use, water levels and ground contamination, soil cleanliness and the use of soil samples. Hydrology including lakes rivers and water cycles. Geology including structure, conditions and ground water. Earth forces and natural phenomenon including landslides, tidal factors and earthquakes. Weather including climate change, temperature, rainfall and wind.

3. Construction design principles

Criteria

3.1 **Benefits** of good design

Range:

Benefits - efficiency**,** aesthetics, sustainability, wellbeing and improved quality of life, value for money local/community improvement, on budget.

What do learners need to learn?	Skills
The benefits of good design and the potential implications of poor design, reduced saleability, reduced efficiencies, 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 and end users). Efficient use of materials and quantity control. Factors that can impact on the profitability of projects – i.e. over specification leading to higher costs, difficulty of assembly leading to increased timescales and increased budgets, 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.	CSC EC6 MC2 MC8 MC10

3.2 **Design principles**

Range:

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

What do learners need to learn?	Skills
Factors that need to be considered during the design of building services and how the range of design principles are influenced by the end design including buildability. The stages and outcomes of the Royal Institute of British Architecture (RIBA) plan of work. To include: • Environmental protection: sustainable technologies and materials, energy sources, energy reduction materials, local and natural environment • Safety: safe construction methods • Aesthetics (design features, materials used, colour) • Buildability manufacture: installation, feasibility, modern methods of construction, inclusivity and construction timescales • Provisions (services and access) • Traditional versus Modern methods (timber frame, thin joint, etc.) of construction, (offsite construction) • Listed Buildings Regulations • Heritage Regulations • Local Authority restrictions • Life cycle costs and life cycle CO2 emissions	CS3 EC6 DC1 DC6

3.3 Role of different **disciplines** involved in design

Range:

Disciplines - contractors and all operatives, architects and all professional occupations, planners and building inspectors, manufacturers, mechanical building services engineer, electrical building services engineer, mechanical design engineer (Building Services), mechanical engineer design coordinator, mechanical engineer CAD technician, BIM designer, retrofit coordinators, retrofit assessors

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

3.4 Design **process** from conception to completion

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

What do learners need to learn?	Skills
The key stages of the design process from initial enquiry to completed design and factors that may impact or influence design changes; Construction Design and Management (CDM), budget, and end user requirements including: • Site analysis: location, size, topography • Planning: local planning, listed buildings, environmental factors and regulations how to make a planning application, how the approval is gained, appeals procedures. • What a feasibility study is • Animals/infestation/ Site of Specials Scientific Interest (SSSI)/protection • Planning for utilities and connecting to services (water, drainage, gas, electric) • Planning for building services • What is the frontage line and building line and how are these determined? • Project planning, Gantt charts, Critical path, use of information for costing and efficient resources	CSA EC3 EC5 EC6 MC7

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

Range:
Life cycle assessment - raw material supply, manufacture of construction products, the construction process stage, occupation, demolition, when the materials are disposed of or recycled, energy usage, CO2 emissions.

What do learners need to learn?
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 inform on planning greener and smarter building with less impact overall on the environment. Including material acquisition, manufacturing, use and final disposition.

4. Construction and the built environment industry

Criteria

4.1 Structure of the construction industry

What do learners need to learn?	Skills
The structure of the construction industry, including roles and business types (sole traders, contractors, sub-contractors, small, medium and large organisations) and roles and client types (private, commercial, public limited companies and the Government). Size and scale in determining who is involved. The role of building regulators and the relationship with the customer/client (ensuring safety, health and welfare in and around built environments). The range of work undertaken - commercial, residential, industrial, health, retail, recreational and leisure, utilities and transport, new build, retrofit.	MC3

4.2 How the construction industry serves the economy as a whole

What do learners need to learn?
How the construction industry contributes to the UK economy with reference to wealth generation from construction developments, area regeneration, improvements in infrastructure, and community developments, including housing, transport, leisure facilities, educational establishments and hospitals. Factors that impact growth of the industry, including political changes, developments in technology/practice, skilled labour resources and 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 national infrastructure projects.

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

Range:

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

What do learners need to learn?	Skills
The integration of all partners of the supply chain in the building process. An awareness of the importance of effective planning (inventory management) and collaborative working (integrated systems and agreed roles and responsibilities and change management approaches) ensuring that the project is completed to standards, budget and on time, and the consequences of poor planning and communication (disruption, increased costs, reputation).	CSD

4.4 Procurement of projects within the construction sector

Range:

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

What do learners need to learn?	Skills
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. 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.	MC9 MC10

4.5 Managing change requests from various parties

What do learners need to learn?	Skills
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.	CSC DC3

4.6 Roles and responsibilities of the **construction professions and operatives**

Range:

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

Construction operatives – joiner, plasterer, tiler, bricklayer, plumber, electrician, heating and ventilation fitter, gas fitter, decorator, site supervisor, trade supervisor.

What do learners need to learn?

The key job roles (position or part played) and responsibilities (types of tasks and duties they are expected to complete) of construction professionals and operatives and the stages they may be involved in a construction.

4.7 The **role of Continuing Professional Development (CPD)** in developing the knowledge and skills of those working in the sector

Range:

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

What do learners need to learn?

The role of CPD to individuals, companies and the building industry as a whole.

Importance of CPD in maintaining occupational competence and best practice, and the link to keeping clients/customers/public safe.

CPD and career progression.

Workforce planning

Providers of CPD i.e.
- Professional bodies
- Accreditation bodies
- Certification bodies.
- Manufacturers
- In house/ toolbox talk

Types of CPD, including formal, in house, qualifications, work experience, self-learning, and chartered etc.

4.8 Building information modelling (BIM)

What do learners need to learn?	Skills
The aspects of BIM and the effect it has on real time project delivery in a collaborative way and BIM government levels 1-3. Building passporting and Data warehouse The collaborative role of BIM in delivering real time projects: • Digital Plan of Works (DPoW) • Employer’s Information Requirements (EIR) • Common Data Environment (CDE)	CSD

4.9 **PESTLE** factors

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

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

4.10 **Documentation** used in construction projects

Range:

Documentation: Take off sheets, contracts, schedule of rates, estimates, quotations, delivery notes, purchase orders, bill of quantities, wiring diagrams.

What do learners need to learn?

Documents used through the construction process, and when each are used including their purpose.

4.11 Procedures for handing over projects to clients

What do learners need to learn?

The procedure for handing over projects to client including contents and purpose of operation and maintenance manuals, demonstration of use and client understanding, guarantee periods, snagging.

5. Construction sustainability principles

Criteria

5.1 Sustainability when **planning** and delivering a construction project

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

What do learners need to learn?	Skills
The importance of sustainability in relation to the stages of project development. Including design, planning and delivery and across different types/scales of construction project as well as environmental protection. The relevance of local sourcing, resource protection, re-use, and refurbishment of materials. The common sustainability assessment methods used in planning and delivering a construction project including BREEAM, LEED, TRADA, and Well building standards Carbon footprints The purpose of PAS 2035 and PAS 2038	MC3

5.2 Types of **sustainable solutions**

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

What do learners need to learn?	Skills
The use of sustainable solutions including prefab construction, self-heal concrete, energy efficiency systems, insulation, green roofs, greywater harvesting systems, use of soakaways, sustainable drainage, and smart glass/electrochromic glass. How sustainable materials are used including recycled bricks and tiles/slates and timber products in construction of building and roofs/locally sourced (reducing carbon footprint).	CSB

5.3 **Environmental legislation**

Range:

Environmental legislation - Environmental Protection Act, Climate Change Act, Clean Air Act, Water Act, Building Regulations, COSHH, WEEE, Hazardous Waste Regulations, Control of Pollution (Oil Storage) (England) Regulations 2001, best practice for pollution prevention.

What do learners need to learn?	**Skills**
The obligations and responsibilities of employers and employees in relation to construction/maintenance activities and environmental protection measures including hazardous waste, material considerations, disposal methods, BOCs, PPE, user guide instructions, specific risk assessments. Key requirements of environmental regulations that must be adhered to whilst working in the building engineering services industry.	**EC5**

5.4 Environmental performance **measures**

Range:

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

What do learners need to learn?	**Skills**
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). The types of schemes that can be used to certify levels of environmental performance in construction, including BREEAM, passivhaus and leadership in energy and design.	**EC5**

5.5 **Principles** of heritage and conservation

Range:
Principles - restrictions, permission, legislation and guidance**.**

What do learners need to learn?	**Skills**
Heritage and conservation considerations associated with listed and historical buildings (types of grades and restrictions) and maintenance of existing stock and how current regulations (Planning Act and Heritage Protection Bill) affect the selection of materials used for building activities.	**EC5**

5.6 Lean construction

What do learners need to learn?	**Skills**
The principles of lean construction. (efficiency, best value, ensuring the work environment is clean and safe, improving planning and continuous review and improvement). The techniques aimed at maximising value and minimising waste within the building services industry including just in time deliveries, reducing errors and recycling. How advanced manufacturing techniques (control systems, high precision technologies, sustainability technologies, offsite manufacturing, computer aided design) benefits lean construction.	CSB

5.7 **Waste management legislation**

Range:
Waste management legislation - waste, Electronic and Electrical Equipment (WEEE),
F Gas.

What do learners need to learn?
Key requirements and duty of care of waste management legislation including which materials may contain hazardous waste. Key requirements to include: • Waste carriers license • Separation and recycling waste • Exemptions

5.8 **Waste management**

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

What do learners need to learn?	**Skills**
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, and correct waste disposal. All current and statutory waste management systems, the way they are used in the disposal of construction materials including hazardous or specialised waste disposal. The circular economy principles and the waste hierarchy. Prioritising reduce, re-use, recycle, recover, preferred over basic disposal.	EC2 EC3 EC5

5.9 **Energy** production and energy use

Range:
Energy - wind, water (hydro), solar, nuclear, fossil fuels, ground and wind source energy.

What do learners need to learn?	**Skills**
Types of energy produced including nuclear, heat and power combined, fossil fuels including alternative methods such as wind, solar, hydroelectric, and their impact when used (i.e. availability, impact on environment, costs). Reasons for choosing energy sources including the advantages and disadvantages of each method (i.e. localism, regionalism). Hydrogen and how it is produced: reforming methane vs electrolytes, with pros and cons (cost vs CO2). Bio-methane Biomass Carbon capture and storage CO2 emissions for all, including projections for the next 30 years.	**EC6**

5.10 **Renewable energy** and **energy conservation**

Range:

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

Energy conservation - Rainwater and grey water recycling, heat recovery, energy efficient lighting, electric vehicle charging points, appliance efficiency ratings.

What do learners need to learn?	Skills
The different types of renewable energy and how they are used to improve energy efficiency in buildings. The importance of efficient design and the use of innovative products and services during the process. The different heat insulation materials used for systems and buildings. The different types of insulation materials used for ductwork, pipework, cables, building structure insulation. Their purpose, benefits and limitations. The implications of using new insulation materials on existing building services systems. Methods available for capturing surface water and recycling used water. The uses of captured and recycled water in properties. The technologies used: High carbon • Natural Gas / LPG • Fuel oils - Solid fuels (coal and peat) Low carbon • Solar thermal • Solid fuel (biomass) • Heat pumps • Electricity (from non-renewable sources) Hydrogen fuel cells • Combined heat and power (CHP) • Combined cooling, heat and power (CCHP) Zero Carbon – • Electricity – wind • Electricity – tidal • Hydroelectric • Solar photovoltaic	MC6 DC1 DC6

5.11 **Digital technologies**

Range:
Digital technologies

Internet of Things (IoT) - Building services system controls, smart meters, hubs/routers
Control and monitoring systems - Smart meters, building management system, automated controls, movement sensors.

What do learners need to learn?	Skills
System controls and building monitoring systems (BMS) used to improve energy efficiency in buildings, the monitoring patterns of usage and the use of innovative products and services during the process. Automated controls and settings to maximise efficiency and movement sensors used to switch building services on and off when required. The environmental technologies that could be used along including devices connected via the Internet of Things (IoT).	MC6 DC1 DC6

6. Construction measurement principles

Criteria

6.1 Accurate and appropriate measurement.

What do learners need to learn?	Skills
The benefits of accurate measurements to contractors, the client/customer, to profitability and project success. Including accuracy in site/location/areas measurements to accurately calculate material quantities to enable accurate costing of construction projects (including use of job, batch, activity, life cycle and other types of costing techniques depending on the project) and the implications of not having accurate measurements – in terms of costs, time, and safety.	CSC MC1 MC9

6.2 Standard **units of measurement** and **measurement techniques**

Range:

Units of measurement - mm millimetres, cm centimetres, m metres, km kilometres, g gram, kg kilogram, tn tonne, ltr litres, sq square and cm cubic metres, s time, N/m2 pressure, N force.

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

What do learners need to learn?	Skills
The types of units of measurement and how these are applied and used in construction projects including methods of obtaining measurements in differing situations (height, length, distance, area, volume, weight, mass, quantity, CO2 emissions, insulation). Methods of calculating units from data sources.	MC1 MC2 MC3 MC4

6.3 **Measurement standards**, guidance and practice

Range:
Measurement standards - scale, tolerances.

What do learners need to learn?	**Skills**
How to use standardised scales for recording or displaying measurements, including measurement rules. How tolerances are applied and implications of not meeting tolerances. Use common scales: 1:1 1:2 1:5 1:10 1:50 1:500 1:1250 1:2500 to communicate information by drawings to BS1192 Drawing sizes used to display information and detail.	EC1 MC1 MC3 MC4

7. Building technology principles

Criteria

7.1 **Construction methods**

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

What do learners need to learn?

Applications, benefits and limitations and procedures of both traditional and modern construction methods including the use of robotics during the construction process.

Types of traditional and modern construction methods including historic buildings pre and post 1920.

Onsite – timber frame, brick and block, container straw bale, robotics

Off-site – pre-assembled, precast, modular, panel systems, 3D printing

Renovation and refurbishment - upgrades, cosmetic and structural changes

Maintenance – fabric services and upgrades

7.2 **Forms** of construction

Range:
Forms - substructure, superstructure, infrastructure, internal/external walls, external work.

What do learners need to learn?

Current forms of construction and their use for both built environment and civil engineering structures.

Substructures: types of foundations, basements, retainer wall

Superstructure: roofs, walls, floors, windows, doors and 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)

Supports and fixings associated with forms in range and building services component.

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

Range:

Approved Documents - part A – Structure, part B – fire safety, part C – site preparation and resistance to contaminates 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 K – protection from falling, collision and impact, part L – 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.

What do learners need to learn?	**Skills**
The purpose of all current UK Building Regulations in renovations and construction of buildings and building services.	CSB EC5

7.4 **Building standards**

Range:

Building standards - BS 1192-4:2014. Collaborative production of information Part 4: Fulfilling employer's information exchange requirements using COBie – Code of practice, BS 7000-4:2013 Design management systems. Microgeneration Certification Scheme (MCS) BS 7671.

Guide to managing design in construction, BS 7913: Guide to the Conservation of Historic Buildings, BS 8536-1:2015 Briefing for design and construction.

Code of practice for facilities management (Buildings infrastructure), BS 8541, BS 9999: Code of practice for fire safety in the design, management and use of buildings, BS ISO 55000:2014 Asset management.

Overview, principles and terminology, BS ISO 16739:2013 Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries, BS ISO 17772 - Indoor environmental quality, International Organisation for Standardisation ISO, ISO 14001:2015 Environmental management systems.

Requirements with guidance for use, ISO 19650, ISO 9001, ISO 50001 Energy Management, PAS 91, PAS 180:2014 Smart cities – Vocabulary, PAS 181:2014 Smart city Framework, PAS 2035, PAS 2038.

Guide to establishing strategies for smart cities and communities, PAS 182 Smart city data concept model, PAS 1192-5:2015, PAS 2080 Carbon management in Infrastructure, PAS 8811:2017 Temporary works, PD 7503:2003 Introduction to knowledge management in construction, BIM Level 2.

What do learners need to learn?	Skills
Current British Standards including waste management, BIM, fire safety. International Standards which includes standards for structures, materials, sustainability etc. and Common minimum standards used for public sector projects. Their purpose and benefits (e.g. guidance, pushing up standards etc.) in construction and renovation.	EC5

7.5 **Trade Associations** and **Professional Engineering Bodies** in relation the BSE sector

Range:

Trade Associations - 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 - 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).

What do learners need to learn?
The trade associations, professional engineering institutions and other sources of information and their responsibilities in relation to the BSE sector. The advice and guidance on technical safety and legislative aspects.

7.6 Manufacturers’ instructions

What do learners need to learn?	Skills
Type of manufacturers’ instructions (maintenance, operation and installation instruction manuals) and their purpose in the construction and maintenance of buildings and services (health and safety).	CSA

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

Range:

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

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

What do learners need to learn?
The different types of building materials and building fabrics and the implications for the application, installation and maintenance of Building Services Engineering systems including supports, fixings and hazards.

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

Range:

Approved documents and guidance - part A - structure, part B - fire safety, part C - site preparation and resistance to contaminates and moisture, part E - resistance to the passage of sound.

What do learners need to learn?	Skills
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.	CSA EC5

8. Construction information and data principles

Criteria

8.1 Data

What do learners need to learn?	Skills
Key elements of data, including accuracy, generalisation, interoperability, level of detail and metadata used to inform construction and building services processes. Different sources that data can be generated from including, • Design and construction processes • Building Information Modelling • Post occupancy evaluation • Utilities, building services, meters, building management systems. • Infrastructure and transport systems. • Enterprise systems such as purchasing systems, performance reporting, work scheduling. • Maintenance and replacement systems. • Operational cost monitoring. • ICT systems and equipment. Data from these sources can be used to understand behaviour, assess performance, improve market competitiveness, allocate resources, and determine costs.	MC5 MC6 MC9 EC4 EC5 DC3 DC4

8.2 Sources of information

What do learners need to learn?	Skills
Be able to interpret types of information and data sources used within construction and building services projects: • product data • manufacturer’s specifications • client’s specifications • Common Date Environment • Building Information Modelling (BIM) • Gantt charts • Critical path networks • Certification and commissioning data • Test data schedules • Condition reports • Carbon emissions Use data sources to calculate outcomes or costs	CSC EC1 EC2 EC3 DC1 DC3

8.3 **Data** management and confidentiality

Data - physical storage, virtual storage.

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

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

8.4 **Drawings, circuit diagrams and schematics**

Range:

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

What do learners need to learn?	**Skills**
Interpret Building Services Engineering information and data using scale, abbreviations, and BS symbols. The conventions, symbols and terminology needed to aid interpretation.	MC3 MC6 MC7 DC1 DC2

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

Range:
Digital systems - smart controls, BIM, CAD.

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

What do learners need to learn?	**Skills**
Basic programming including the set-up requirements of digital systems for BSE systems and which IT resources to use.	DC1 DC6

9. Relationship management in construction

Criteria

9.1 Stakeholders

What do learners need to learn?	Skills
The different types of stakeholders including client, construction team, suppliers, community and end user in construction projects.	CSD EC1

9.2 Roles, expectations, and interrelationships

What do learners need to learn?	Skills
The roles, expectations, and interrelationships of all stakeholders throughout the construction project delivery at design stage, through construction, to handover and in use. To include: • Hierarchy of project management • Promoting good relationships across the project • Cost control measures • Time management methods • Handover processes • Public relations – to include behaviour of employees outside of work hours • Follow up and review	CSD EC1

9.3 Collaborative working to project delivery and reporting

What do learners need to learn?	Skills
The importance of a collaborative approach to project delivery and reporting (delivery, reporting, providing information at various stages in the development) and how this is applied in practice (with the use of BIM and workflow software packages as well as face to face methods).	CSC CSD EC1 EC2 EC3 DC3

9.4 Customer service principles

Range:

Customer service principles - good product knowledge, building trust, meeting timescales, good communication, efficiency, honesty and integrity.

What do learners need to learn?	**Skills**
The basic principles of good customer service and the benefits of good customer service including, repeat business, good reputation, satisfied customers and employees.	CSC EC1 EC6

9.5 Team work to team and project performance

What do learners need to learn?	**Skills**
The importance of good team work to team and project performance (efficiencies, morale of staff, creativity, accountability open communication common goals) and the consequence of poor teamwork (conflict and tension, low engagement, lack of trust) and how it impacts on a construction project (effects of productivity and efficiency).	**EC2** **EC6**

9.6 Team dynamics

Range:

Team dynamics - knowledge of trade/business/product/service, accountability, cooperation, trust, support, reliability, effective communication, active participation, adaptability.

What do learners need to learn?	**Skills**
Qualities and characteristics of good team dynamics, including what is expected of a team member, team structure, what qualities are needed and how these qualities are demonstrated.	**EC2** EC6

9.7 **Equality, diversity and representation**

Range:

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

What do learners need to learn?
Current equality and diversity legislation and the protected characteristics detailed under the Equality Act, Employment Rights Act, Human Rights Act and trade unions, including its application in the workplace.

9.8 **Negotiation techniques**

Range:

Negotiation techniques - distributive negotiation or win-lose approach, lose-lose approach, compromise approach, integrative negotiation or win-win approach.

What do learners need to learn?	**Skills**
Methods of negotiation and how they are used within the construction industry (acquiring land, obtaining planning permission, awarding contracts, negotiating change orders, time extensions and resolving disputes).	EC6

9.9 **Conflict management techniques**

Range:

Conflict management techniques - preventative measures, compromise, problem solving, avoiding, competing, forcing, alternative dispute resolution (informal discussions, mediation, conciliation, arbitration).

What do learners need to learn?	**Skills**
Conflict management techniques including preventative measures and common reasons for conflicts (e.g. ambiguous contract terms, breach of contract, late supply of materials, programme delays). Using digital methods to resolve conflict including the use of BIM for controlling conflict before it escalates. Use when construction projects change/alter.	CSD EC6

9.10 **Methods** and **styles** of communication

Range:

Methods - verbal (pitch and tone, questioning types open/closed), and non-verbal (body language, eye contact, facial expressions).

Styles - formal, informal.

What do learners need to learn?	**Skills**
The styles and methods of communication, type of communication (face to face, email, letter, telephone, drawn information) and suitability for different situations that may arise throughout a typical construction project. Digital project management and how this can be used to communicate as part of the construction project teams.	EC1 EC3 EC6 DC1 DC3

9.11 Employment **rights and responsibilities**

What do learners need to learn?	**Skills** **EC5**
The current employment rights and responsibilities of employees and their employer. Employment Rights – wage rules (minimum wage, pension), time off (holiday, parental leave, rest breaks etc.), equal rights (against harassment and discrimination), health and safety and welfare, and access to representation in times of grievance (trade union representation/independent representation). Responsibilities: Employer to employee – work, pay, health, welfare and safety provided Employee to employer – working to contract, complying with health, safety and welfare, confidentiality and reasonable behaviour as set out in the company handbook.	

9.12 Ethics and **ethical behaviour**

What do learners need to learn?	**Skills**
Ethics and ethical behaviour- (honesty, integrity, equality, loyalty, fairness, caring, respect, adherence to laws, commitment, reputation, accountability) in the construction industry.	CSD

9.13 Sources of information

What do learners need to learn?

How sources of information, including web based and social networks contribute to the knowledge sharing/stakeholder experience (sharing ideas and knowledge, advertising and promotion, getting customer reviews and feedback) within the construction industry.

10. Digital technology in construction

Criteria

10.1 **Internet of things**

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

What do learners need to learn?	Skills
The use of technology to capture data in a completed building and how this data is used for the purpose of manufacture and delivery. The different uses of technology connected to the internet of things (smart building, smart applications and systems) and their use and role in the construction industry (productivity, assisting just in time, asset management, maintenance, smart equipment smart concrete.)	DC1 DC3 DC5

10.2 **Digital engineering techniques**

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

What do learners need to learn?	Skills
Current Digital engineering techniques and their application in the construction industry: Simulation - structural analysis Animation - visualisation of structural behaviour Surveying - laser level and measuring and CAD modelling (2D drawings 3D modelling), drones. Artist impression	MC6 DC1 DC2 DC6

10.3 Opportunities for the use of **technology**

Range:

Technology - machine manufacturing through robotics**,** CADCAM**,** computer modelling**,** smart technologies.

What do learners need to learn?	**Skills**
The benefits of using current technologies from other industries (accuracy, accessibility, efficiency, reducing risk) and how they can be adapted for use in the construction and the built environment.	MC6

11. Construction commercial/business principles

Criteria

11.1 **Business structures**

Range:
Business structures - sole trader, partnership, limited company (PLC. Ltd.), small and medium enterprises (SMEs), not for profit organisations, not-for-profit organisations/ community interest company (CIC), franchise.

What do learners need to learn?

Typical business structures in the built environment and construction industry.

- Ownership
- Management of the company
- Legal status
- Liability
- Advantages/Disadvantages

11.2 **Business objectives**

Range:
Business objectives - financial and social, organisation culture, quality, innovation, compliance, sustainability.

What do learners need to learn?	**Skills**
The business and corporate objectives used to measure performance of an organisation in the construction industry: Financial – private organisations (profit, growth and innovation, market leadership) and not-for-profit (value for money, increased access, reduced poverty). Calculating targets for performance. Social – private organisations (providing employment) and 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.	MC2 MC6 MC9

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.	

11.3 Business values

What do learners need to learn?	Skills
The fundamental business values including financial stability, customer service, care for life, ethics and transparency, codes of conduct, commitment to the customer, collaborative working.	CSD

11.4 **Principles** and **examples** of corporate social responsibility

Range:
Principles – social, economic and environmental factors, design, sustainability.

What do learners need to learn?
The basic principles of corporate social responsibility (CSR) and examples of use in the construction industry. Design – community led, inclusive, meets local needs Social, economic and environmental – positive impact Sustainability – use of local trades/suppliers and materials.

11.5 **Principles** of entrepreneurship and innovation

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

What do learners need to learn?
Principles of innovation and entrepreneurship and role it plays in the construction industry (improved product service, increased growth/profit, advancements in industry).

11.6 Measuring success

What do learners need to learn?	Skills
How organisations in the built environment and construction industry use benchmarking, (KPI's, standard setting, target setting, input, output and process) when measuring business success.	CSA

11.7 Project management

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

11.8 Quality management

What do learners need to learn?	Skills
The quality management systems and techniques used in business including: • Self-assessment • Internal audit • External audit • Quality control • Quality improvement • ISO 9000 The purpose of quality management systems - to maintain the standard or quality of the work in a consistent manner.	CSD

12. Building Services Engineering (BSE) systems

Criteria

12.1 Building Services Engineering **systems**

Range:
Systems -

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

What do learners need to learn?	**Skills**
The layout and basic components included in a range of BSE systems. What these systems are used for and when they are used. Key differences in operation and advantages and disadvantages of each system type. Integration between systems including common skills.	CSA CSB

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

What do learners need to learn?

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

- environment
- other trades
- users including loss of services or essential systems

12.3 Mechanical principles of **components**

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

What do learners need to learn?

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

12.4 Electrotechnical principles of **components**

Range:
Components - cable types, accessories, containment.

What do learners need to learn?

Electrotechnical principles of components including their characteristics, applications and functions.

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

12.5 **Electrical supply.**

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

What do learners need to learn?

The different types of electrical supply.

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

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

12.6 **Earthing arrangements**

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

What do learners need to learn?

The different types of earthing arrangements and the attributes of each system. The nature of the earth return path in each system and what system components are included in each arrangement.

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

12.7 **Cables, accessories and equipment** used in older electrical installations

Range:
Cables, accessories and equipment - lead sheathed cable, Vulcanized India Rubber (VIR) insulated cable, cable colours, BS 3036, re-wire able fuses, non-fire rated consumer units/distribution boards.

What do learners need to learn?	**Skills**
The common cable types and sizes (metric, imperial) for a range of circuits. 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.	MC2 MC4

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

Range:

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

Components - 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, room thermostats).

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

What do learners need to learn?

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.

13. Maintenance principles

Criteria

13.1 **Types of maintenance**

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

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

13.2 **Maintenance plans**

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

What do learners need to learn?

The requirements of maintenance plans, either as planned or reactive. Their content and typical tasks for BSE systems.

13.3 Typical timeframes between maintenance tasks.

What do learners need to learn?

The frequency for completing maintenance tasks on all BSE systems as listed in the range. Including the requirements for landlord safety checks on systems such as gas appliances and electrical systems at regular intervals.

13.4 **Documentation** required for maintenance and verification of maintenance activities

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

What do learners need to learn?	**Skills**
The reference documents and forms needed when completing both planned and reactive maintenance.	EC4

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

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

What do learners need to learn?	**Skills**
The actions required when faults cannot be rectified and the implications this can have on the customer and the business: • Time • Costs • Downtime of systems • Loss of income • Increased hazards • Loss of services	MC2 MC9 EC1 EC3 EC4

14. Tools, equipment, and materials

Criteria

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

What do learners need to learn?	Skills
The methods to ensure tools, equipment and materials are fit for purpose and the required checks that are undertaken to ensure this. **Tools and equipment** • Portable appliance testing (PAT) • Calibration of instruments • Cleanliness checks • Daily checks including visual inspection and operation check • Condition reports • Asset registers **Materials** • Fit for purpose • Associated hazards • Quantity • Specialist requirements The procedure that should be applied for tools and equipment that fail safety checks The safe isolation procedure when replacing attachments to power tools: • Drill bits • Cutting blades The methods of safe supply for electrical tools and equipment on site: • battery-powered • 110 V • 230 V	MC1

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

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

What do learners need to learn?	**Skills**
The importance of correct tool maintenance and the methods of maintaining a range of tools used in BSE, including: • Safety • Prolonged tool life • Accuracy	

Links to occupational specialisms

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

BSE specific core content

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

Guidance for delivery

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

Formative assessment – oral Q&A, SmartScreen worksheets (samples available) 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 BSE systems and components are available
- Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration
- The provision must represent the type of equipment currently available in the UK BSE industry
- Current and emerging BSE technology should be included in delivery where possible

Suggested learning resources

Books

- Michael Maskrey, *The City & Guilds Textbook: Plumbing Book 1 for the Level 3 Apprenticeship (9189), Level 2 Technical Certificate (8202) and Level 2 Diploma (6035)*, City & Guilds, 2019
- Peter Tanner and Stephen Lane, *The City & Guilds Textbook: Plumbing Book 2 for the Level 3 Apprenticeship (9189), Level 3 Advanced Technical Diploma (8202) and Level 3 Diploma (6035)*, City & Guilds, 2019
- Peter Tanner, *The City & Guilds Textbook: Book 1 Electrical Installations for the Level 3 Apprenticeship (5357), Level 2 Technical Certificate (8202) & Level 2 Diploma (2365)*, City & Guilds, 2018
- Peter Tanner, *The City & Guilds Textbook: Book 2 Electrical Installations for the Level 3 Apprenticeship (5357), Level 3 Advanced Technical Diploma (8202) & Level 3 Diploma (2365)*, City & Guilds, 2019

Websites

- Institute for Apprenticeships and Technical Education (IfATE) **https://www.instituteforapprenticeships.org/**
- Building regulations website: https://www.gov.uk/government/collections/approved-documents
- Planning Portal https://www.planningportal.co.uk/
- Gas Safe Register https://www.gassaferegister.co.uk/
- British Standards Institution **https://shop.bsigroup.com/**
- Chartered Institution of Building Services Engineers (CIBSE) https://www.cibse.org/
- Association of plumbing and heating Contractors https://www.aphc.co.uk/
- NICEIC http://www.niceic.com/
- The carbon trust **https://www.carbontrust.com/**
- **https://energysavingtrust.org.uk/**
- https://www.hse.gov.uk/
- Office of Gas and Electricity Markets – **https://www.ofgem.gov.uk**

351 Air conditioning engineering

Level:	3
GLH-combined with refrigeration (358):	700
Assessment method:	Practical assignment

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

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

- How does an air conditioning technician achieve a leak-free system?
- What are the requirements of the F-Gas Regulations?
- What tools and equipment does an air conditioning technician need?

Underpinning knowledge 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:

2. Install air conditioning systems
3. Commission air conditioning systems
4. Maintain air conditioning systems

Completion of this specialism will give learners the opportunity to develop their Maths, English and Digital Skills.

Specialism content

Outcome 1

Common knowledge criteria

Air conditioning systems

1.1 The function and operation of **air conditioning systems**

Range:

Air conditioning systems - direct expansion, flooded, (centralised plant, air handling units (AHUs), fan coils, chilled beams), heat pump (ground, air and water source), VRV/VRF air conditioning, water chillers.

What do learners need to learn?

The range of air conditioning systems in common use.

The function and operation of air conditioning systems and how they interact in different systems and applications.

1.2 Air conditioning and ventilation in a modern economy

What do learners need to learn?

The uses of air conditioning and ventilation including the difference between cooling for human comfort and for process control in industry.

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.

Air conditioning science

1.3 **Scientific principles** of air conditioning

Range:

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

What do learners need to learn?	**Skills**
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 - HFC, HFO, HC, natural refrigerants • Primary refrigerant ideal properties • Secondary refrigerants • Secondary refrigerant ideal properties • Environmental impact • Ideal properties of lubricants Filtration - air filter (panel, bag, HEPA, carbon), water, refrigerant Psychometrics - properties of air: physical make-up, moisture content, temperature Measuring devices: sling psychrometer, hygrometer. Psychrometric chart plot points: wet bulb temperature, dry bulb temperature, percentage saturation, moisture content, specific volume, enthalpy, dew point, apparatus dew point. Psychrometric processes - sensible, latent. 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. 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

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

What do learners need to learn?

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).

1.5 Types of **data**

Range:
Data - measurements, diagrams, calculations, tools, charts, tables.

What do learners need to learn?

Types and data and how to apply them. The SI system of measurement and methods to apply to a range of calculations.

Measurement:

- **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/s2), pressure (Pascal), specific volume (m3/kg) energy (J), enthalpy (kJ/kg), conductivity (W/mk), energy rate (W).
- **Cooling and heating formulae -** (Q=mCt, Q=mL, Q/s=W).
- **Tools, charts and tables -** refrigerant comparators (slides and apps), 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.

Skills
MC4
MC6
MC7

Legislation, Regulations and Standards

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

Range:

UK and international standards and Approved Codes of Practice (ACOPS) - Health and Safety at Work Act, The Electricity at Work Regulations, Control of Substances Hazardous to Health (COSHH) Regulations, Work at Heights Regulations, Personal Protective Equipment at Work Regulations (PPE), Lifting and Manual Handling Operations Regulations, Provision and Use of Work Equipment Regulations (PUWER), Control of Asbestos at Work Regulations, Health, Safety and Welfare Regulations, Health and Safety (First Aid) Regulations, Confined Spaces Regulations, Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR), F-Gas Regulations, Montreal Protocol.

What do learners need to learn?	**Skills**
Current health and safety and environmental legislation that apply to all aspects of the air conditioning industry. Relevant UK and international standards, and Approved Codes of Practice (ACOPS) related to air conditioning systems including indoor air quality, bacteria in water and asbestos.	EC4 EC5

1.7 **Environmental technologies** employed in the sector

Range:

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

What do learners need to learn?

The various energy efficiency methods used to reduce power consumption and environmental impact, reducing heat gain, cooling load or energy use.

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.

1.8 Supply and storage of energy from **renewable resources**

Range:

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

What do learners need to learn?

Supply and storage of energy from a range of renewable energy sources.

Mechanical generation of electricity principles and its application to renewable resources such as 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).

DSR/DSM (demand side response/demand side management).

1.9 Air conditioning design to reduce environmental impact

What do learners need to learn?

Low GWP refrigerants and renewable energy and heat recovery and how they reduce the carbon footprint of an air conditioning system to include an overview of renewable source energy, heat recovery, low GWP refrigerants (HFO, HC, natural refrigerants).

Use of low GWP 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.

1.10 The principles of operation of **heat pumps**

Range:
Heat pumps - ground source, air source.

What do learners need to learn?

The operation of heat pumps using a pressure enthalpy chart and compare potential heat pump efficiency against traditional heating methods, to include:

- gas boiler
- electric heating.

1.11 Fundamental working principles of **electrical controls** and **components** and motor **starting arrangements**

Range:
Electrical controls - pressure switches, thermostats, flow switches, over current/over temperature (bimetal, PTC, 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).

What do learners need to learn?

The function and operation of the stated electrical controls and components and motor starting systems and their applications.

Specific knowledge criteria for performance outcomes

System Installation (Outcome 2)

1.12 Checking multiple circuits and systems for leakages

What do learners need to learn?

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

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

Range:
Tools and equipment - wall/ceiling fixings, pipe benders, brazing equipment (LPG, oxy-acetylene), pipe fittings, mechanical (flare, compression fittings) and braze jointing of pipework.

What do learners need to learn?

The methods and types of fixings used in the construction industry and how they can be used to mount air conditioning equipment.

The different types of pipe jointing methods and when one should be used as opposed to another (DSEAR).

1.14 Types of **ductwork** and **pipework**

Range:
Ductwork - plastic, steel, rectangular, circular, oval, rigid, flexible.

Pipework - Copper, steel, aluminium, plastic.

What do learners need to learn?

The different types of duct and pipes used in the RAC industry, and when the different types would be applied (pressure rating, space available).

The different materials used in ductwork - steel, aluminium plastic.

1.15 Know the safety requirements for working with **gases** and heat producing equipment

Range:
Gases - propane, butane, oxy-acetylene, nitrogen.

What do learners need to learn?

The different types of fuel gases used to braze refrigeration and air conditioning pipework.

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.
Procedures - raise the alarm, follow safety evacuation procedures, call emergency services.
Classifications of fires - class A, B, C, D, electrical fires.
Fire extinguisher - carbon dioxide, water, powder, foam.

1.16 **Cable types** and their **termination**

Range:
Cable types - multi-core flex, steel wire armoured, single conductor, twin and earth, braided sheath cable, screened.

Termination - insulated crimps, non-insulated crimps.

What do learners need to learn?

The different types of electrical cable used in the RAC industry and the methods used to fix and terminate cabling safely.

System commissioning (Outcome 3)

1.17 **System operation requirements** to be checked for commissioning

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

What do learners need to learn?	**Skills**
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. 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

1.18 **Visual inspection** of an air conditioning system

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

What do learners need to learn?	**Skills**
How to use the human senses to determine fault conditions. The process of carrying out a visual aural, smell and touch inspection to determine abnormal operation, unexpected operational noises (compressor, fans, bearings, loose panels, vibration, oil seepage, high temperatures, disturbed wiring).	MC2

1.19 Expectations of a steady-state condition for air conditioning and heat pump systems

What do learners need to learn?	Skills
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 of air conditioning, heat pump (ground coil and air source) and water chiller systems to meet the design parameters.	MC6

1.20 Know the impact of operating conditions on system performance

What do learners need to learn?	Skills
How system performance is affected when both internal and external environmental conditions change using a pressure enthalpy chart. How system performance is affected by common system faults using a pressure enthalpy chart. Environmental conditions - higher than design ambient temperatures, lower than design ambient temperatures for condensers and evaporators. Common system faults - blocked condenser, blocked evaporator, shortage of refrigerant, reduced air flow.	MC6

System maintenance (Outcome 4)

1.21 Types of **fault-finding techniques**

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

What do learners need to learn?	**Skills**
Fault-finding techniques and how these are applied in practice. The suitability of different fault-finding techniques for compact water chillers, process coolers, heat pumps (ground source and air source), single split and multi split systems determined by location, fault, refrigerant type and urgency. 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 (sight, sound, touch, smell), manufacturer’s instructions and fault codes, and historical operating and commissioning data to determine and identify a fault condition.	MC2 MC6

1.22 **Cleaning** of **components**

Range:
Cleaning - Coil cleaning fluids, spray washers.

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

What do learners need to learn?

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

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

1.23 Disassembly techniques

What do learners need to learn?

The process for safe isolation of the system electrically and the importance of following manufacturers recommendations, instructions and method statements to disassemble an air conditioning system ready for a repair activity.

1.24 **Techniques** according to use and operation of system

Range:
Techniques - preventative maintenance, reactive maintenance.

What do learners need to learn?

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.

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) and preventive maintenance situations and how to prioritise which fault-finding techniques must be used.

1.25 Referral of a fault to a specialist

What do learners need to learn?	**Skills**
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, and decommissioning.	MC2

Outcome 2 - Install air conditioning systems

Performance criteria

2.1 Sequence and prioritise tasks

What do learners need to learn?	**Skills**
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

2.2 Identify **information requirements** for the task

Range:

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.

What do learners need to learn?	**Skills**
Identify and gather all the information needed from a range of sources to ensure compliance with local and national by-laws and legislation and any specific manufacturer’s requirements.	EC4 EC5

2.3 Produce written **reports** to stakeholders about work completed

Range:

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

What do learners need to learn?	**Skills**
Produce written completion documentation for legal compliance (F-gas records) and customer information (operation instructions).	EC1 EC3

2.4 Measure and mark out **installation requirements**

Range:

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

What do learners need to learn?	**Skills**
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.	MC1

2.5 Connect **components**

Range:

Components - heating and cooling coils.

What do learners need to learn?	**Skills**
The connection of refrigerant, water supply and drainage pipework, electrical power and control cables. Allowance should be made where any of the connections must also connect to external services.	MC1

2.6 Assemble pipework and insert **components** into system

Range:

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

What do learners need to learn?

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.

Join refrigeration pipework and components using brazing, flaring and swaging methods (Cu to Cu, Cu to Fe, Cu to brass, Fe to brass). Purging using OFN to prevent internal scaling. How to prevent components from heat damage while brazing, and the application of pipe insulation materials.

Forming - braze (oxy -fuel), flare, bend, swage, other mechanical joints.

Jointing methods - similar and dissimilar metals with hot and cold joints – mechanical and compression, Cu/Al joints.

Purging - use of oxygen-free nitrogen.

System components - condensing units, evaporators, condensate drains, valves, electrical cabling, drier, pressure switches, pumps, sight glass, vessels.

Fix - vibration damping clamps, pipe saddles, pipe clips, insulated clamps.

Protective measures - wet rag, non-conductive foam, temporary removal of low melting point items.

Temperature sensitive system components: Thermostatic expansion valves, solenoid valves, vibration eliminators, Schrader valves, pressure transducers.

2.7 Adjust **components**

Range:

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

What do learners need to learn?

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.

2.8 Connect **control systems**

Range:

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

What do learners need to learn?	**Skills**
Connect a range of control components including sensors and programmers to the refrigeration and control circuit, and make safe electrical connections as needed.	DC1

2.9 Apply final settings

What do learners need to learn?	**Skills**
Calculate the correct additional charge for an air conditioning system in accordance with manufacturer’s instructions.	MC2

2.10 Confirm system is ready to commission

What do learners need to learn?

Carry out pre-commissioning checks: strength and tightness pressure/leak testing, electrical supply, electrical connections, temperature controllers, cabling before start-up of a system.

Outcome 3 - Commission air conditioning systems

3.1 Interpret a risk assessment

What do learners need to learn? Interpret risk assessments with consideration for responsibilities and persons at risk, applying controls, and recording potential hazards and completion of documentation.	**Skills** EC4 EC5

3.2 Interpret **information** provided

Range:
Information - BS EN378, F-Gas Regulations, contractual specifications, manufacturer's instructions, including bill of materials and site plans.

What do learners need to learn? Interpret regulatory, contractual and manufacturer's specifications and requirements in readiness to carryout system commissioning.	**Skills** EC4 EC5

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

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

What do learners need to learn? Interpret 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.	**Skills** MC6 DC4

3.4 Explore **requirements** of the task

Range:

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

What do learners need to learn?	**Skills**
Use open questioning and listening techniques to ensure that the client's requirements and needs are met.	EC2 EC4 EC5 EC6

3.5 Visually inspect system installation

What do learners need to learn?	**Skills**
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.	

3.6 Establish a **steady-state** operation

Range:

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

What do learners need to learn?	**Skills**
Interpret the data readings recorded to ensure that the steady-state conditions achieved meet the contractual requirements.	MC6 DC3

3.7 Collect **data** from control system

Range:

Data - primary and secondary refrigerant flow rates, temperatures, humidity and filtration/air quality levels.

What do learners need to learn?	**Skills**
Complete measurement of all required parameters such as 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.	MC5 MC6

3.8 Record **data** from commissioning instrumentation

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

What do learners need to learn?	Skills
Use commissioning instruments to collect and record data such as temperatures, systems pressures, flow rates and running currents.	MC5 MC6 EC3

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

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

What do learners need to learn?	Skills
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.	MC5

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

Range:
Adjust - temperature, pressure controls, air flow rates, air distribution, energy efficiency.

What do learners need to learn?	Skills
Undertake appropriate testing and interpret data to adjust the system controls to achieve the correct environment conditions and maximise energy efficiency.	MC6

Outcome 4 - Maintain air conditioning systems

4.1 Produce a **method statement**

Range:

Method statement - scope of works, manufacturer's instructions, contractual requirements, risk assessment, preventative or reactive maintenance, permits to work.

What do learners need to learn? Produce a method statement and risk assessment for either preventative or reactive maintenance through interpretation of system data, customer reports or contractual requirements.	**Skills** EC1 EC2 EC4

4.2 Assess the suitability of **information** available

Range:

Information - previous service records, F-Gas records, customer comments, senses, site logs.

What do learners need to learn? Consider all of the information available with regard to its accuracy, sufficiency, currency and reliability before creating a maintenance plan.	**Skills** EC4 EC5

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

Range:

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

What do learners need to learn? Consider the maintenance plan and manufacturers instruction to compile a list of all materials needed to complete the maintenance task. Assess fitness for purpose of all tools and equipment.	**Skills** MC2 EC3

4.4 Complete **documentation**

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

What do learners need to learn?	Skills
Complete all documentation in line with contractual and legislation requirements.	EC3

4.5 Visually inspect systems

What do learners need to learn?

Carryout 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, and 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.

4.6 Clean **systems**

Range:
Systems - indoor and outdoor coils, air filters, water filters, drain pans, drain lines, unit casings.

What do learners need to learn?

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

4.7 Tighten loose **components**

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

What do learners need to learn?

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

4.8 Adjust **components**

Range:

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

What do learners need to learn?

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.

4.9 Lubricate bearings and other moving parts

What do learners need to learn?

Identify and lubricate all components within the scope of works to include pulley bearings, pumps, electric motors heat recovery wheels, fan motors.

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

Range:

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

What do learners need to learn?	**Skills**
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. Psychrometric calculations using a chart or digital equivalent may be required given the wet and dry bulb temperatures.	MC6 EC5

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

Range:

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

What do learners need to learn?
Inspect the system with regard to other potential hazards such as *Legionella* and SBS and advise or take action as needed.

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

Range:

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

What do learners need to learn?	**Skills**
Consider system information to make an assessment of potential life of system components and make recommendation or take action as necessary.	MC2 MC6 EC5

4.13 **Report** on maintenance activities

Range:

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

What do learners need to learn?	**Skills**
Produce verbal and written reports based on the recorded data and the results of the inspection and works carried out.	EC1 EC2 EC3 EC4 EC6 DC2 DC1

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

Range:

System operation parameters - 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.

What do learners need to learn?	**Skills**
Using a range of information and system data including the senses (sight, touch, hearing, smell) conduct fault analysis to investigate actual or potential faults and construct a plan to put the system back into full operation.	MC2 MC6 EC4 EC5 DC4

4.15 Rectify system

What do learners need to learn?	**Skills**
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, SmartScreen worksheets (samples available) 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 deliver.

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

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	Risk assessment, working safely, PPE
		Working with faults	Fault diagnosis, client requirements, Repair and replace components, use of tools
		Handover/ communication	Communication with customer to diagnose fault
		Reports and information	Maintenance activity report

352 Electrical and electronic equipment engineering

Level:	3
GLH:	570
Assessment method:	Practical assignment

What is this specialism about?

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

Learners will develop their knowledge, understanding and skills in:

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

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

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

Underpinning knowledge outcome

On completion of this specialism, learners will understand:

1. Electrical and electronic equipment engineering knowledge criteria

Performance outcomes

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

2. Install electrical and electronic equipment systems
3. Commission electrical and electronic equipment systems
4. Maintain electrical and electronic equipment systems

Completion of this specialism will give learners the opportunity to develop their maths, English and digital Skills.

Specialism content

Outcome 1

Common knowledge criteria

Health and safety

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

What do learners need to learn?	Skills
Risk assessment requirements and considerations before any work activities are undertaken - use of method statements, necessity for safe isolation of systems being worked on.	EC5

1.2 Specific **risks** associated with electrical and electronic equipment

Range:

Risks – electric shock, fire, burns, static discharge, static shock.

What do learners need to learn?
Risk associated with equipment and systems, and safe working practices to avoid or minimise the risks detailed in the range. Safe isolation and discharge of systems and equipment.

Science

1.3 Electrical/electronic science principles

Range:

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.

What do learners need to learn?	Skills
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.	MC5 MC6

Power in dc electrical circuits.

Resolve simple problems using equations that relate to 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, LED.

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 and resolve series and parallel capacitor circuits.

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, and mutual induced emf.

Construction and basic operation of transformers. Typical applications.

Calculations to determine the effects of transformer turns ratio on voltage and current.

Basic construction, operation and function of the listed semiconductor devices. Recognise common devices, and the means of identifying polarity. Typical applications.

Semiconductor devices: Silicon diode, light emitting diode (LED), NPN bipolar transistor.

Tools, equipment and materials

1.4 **Tools, equipment** and materials used for installation and their purpose

Range:

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

Power tools - hammer drills, electric screwdrivers.

Equipment - test equipment, ICT equipment, soldering irons.

What do learners need to learn?

Selection of correct hand/power tools, equipment and materials required to complete work activities associated with electrical and electronic equipment engineering within BSE.

1.5 Provision of **storage** for equipment, tools and materials

Range:

Storage – temporary Onsite, secure, anti-static, location, logistics.

What do learners need to learn?

Suitable storage requirements to keep tools, materials and equipment secure and safe from damage. Suitable location to allow for logistics and workflow when onsite.

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

What do learners need to learn?

Ensure all products and equipment have been tested correctly in accordance with PAT procedures and in line with the IET Code of Practice for the in-service inspection and testing of electrical equipment (IET COPISITEE).

1.7 **Regulations** and **codes of practice** associated with electrical and electronic equipment installations

Range:

Regulations – BS 7671, PUWER, Electricity at Work Regulations, Electromagnetic Compatibility Regulations.

Codes of Practice and guides – IET COPISITEE, IET CoP Building Integration and Control Systems, IET CoP Connected Systems Integration in Buildings.

What do learners need to learn?	**Skills**
Awareness of the range of regulations and codes of practice that influence selection, erection, design and function of electrical and electronic equipment and associated wiring systems.	EC5

1.8 Operation and handling **requirements** for power tools and equipment

Range:

Requirements - asset register, regular user checks, PAT, IET COPISITEE.

What do learners need to learn?

Safe use of tools in accordance with manufacturer's instructions and industry standards. Frequency of inspection, testing and user checks.

1.9 Principles of electrical **circuits** and **loads**

Range:

Circuits – ring-final, radial, lighting, series, parallel, AC, DC, magnetic effect, temperature effect, voltage drop.

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

What do learners need to learn?	**Skills**
How different circuit arrangements affect voltage and current behaviour. Control of loads by circuit arrangement and the reasons why particular circuit arrangements are selected. 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 load affect current and voltage including resistive, inductive, and capacitive loads. How power factor is induced and how it changes circuit properties such as current, voltage and power. Methods used to reduce power factor.	MC5 MC6

1.10 Principles of electronic components used in equipment

Range:

Components – resistors, capacitors, thermistors, light-dependant resistors (LDRs), all types of diodes, transistors, diacs, triacs, transformers, rectifiers, programmable logic controllers (PLCs).

What do learners need to learn?
Identification and working principles of electronic components used in equipment, including basic circuits using electronic equipment and how to test for basic function.

Systems and products

1.11 Requirements of **systems** in meeting product and building operations

Range:

Systems - lighting, power, heating, cooling.

What do learners need to learn?

Requirements of the systems listed in the range, along with their interfacing equipment. Selection of equipment used to meet energy efficiency requirements/considerations within building regulations and BS 7671.

1.12 **Electrical and electronic equipment,** including related software

Range:

Electrical and electronic equipment - electrical power and lighting controls, heating system controls, monitoring systems (BMS/instrumentation/software), network systems, Wi-Fi extenders, Power over Ethernet (PoE), security and access, point-of-sales.

What do learners need to learn?	**Skills**
Characteristics and purpose of the different types of systems/equipment used in building management and control systems, including the components and software used. Suitability of equipment for installation location and external influences. How components operate within a system and integrate to enable the product and system to operate effectively including different types of connectivity and wireless systems available and also including the internet of things (IoT). Other systems available including Wi-Fi, Bluetooth. The operation of the building systems and their individual components, how these components are connected to each other, if they are hard-wired, connected wirelessly through Bluetooth, or through a central hub. Concepts and development with the IoT.	DC1 DC5 DC6

1.13 Types of **monitoring systems**

Range:

Monitoring systems - BMS, PLCs, fire alarms, emergency lighting, security (intruder/access), heating and ventilation.

What do learners need to learn?

Operation of different types of monitoring systems, how the data is connected between them, and the use of networks within buildings. The types of data produced by systems and how the data is produced and extracted, considering different types of wireless systems available.

1.14 Types of **AV equipment**

Range:

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

What do learners need to learn?

Operation and connectivity of the different types of AV equipment within the range specified. Types of interfaces used between equipment and systems such as audio/video to network adaptors and wireless links.

1.15 Design procedures and factors associated with new and existing power systems, wiring systems and circuits, leading to **compliance with BS 7671**

Range:

Compliance with BS 7671 – assessment of general characteristics, protective measures, selection and erection, special locations, current carrying capacities.

What do learners need to learn?

The requirements of BS 7671 affecting the design of electrical systems and circuits for new installations or the addition to existing circuits and systems. Procedures used to design circuits in accordance with BS 7671 and factors affecting design.

Current carrying capacities as in BS 7671

1.16 Effects of EMI and methods used to reduce the effects to, or admitted by electrical and electronic equipment

What do learners need to learn?

Types of equipment that emit EMI, and their characteristics. Equipment vulnerable to EMI and methods used to reduce the effects such as shielding, segregation, spacing, use of non-metallic (optical) systems, bonding networks.

Specific knowledge criteria for performance outcomes

System installation (Outcome 2)

1.17 **Cable and wiring system component** installation and their supports

Range:

Cable and wiring system components - single and multicore thermoplastic cable, SWA multi-core armoured cable, MICC, FP200 - fire resistant cable, data cable CAT5/6, enclosures (cable tray, cable conduit - (steel and PVC), cable trunking, ladder racking, cable basket).

What do learners need to learn?

Methods of installing cables to a range of wiring and containment systems into a new or existing building including requirements for the installation of wiring in buildings, as in BS 7671.

1.18 **Methods** of terminating cables into accessories

Range:

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

What do learners need to learn?

Different methods for terminating cables into enclosures and accessories, to meet manufacturer’s instructions and industry practices for the cables as ranged in 1.17

1.19 Identification of **electrical supply** and **earthing arrangements**

Range:

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

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

What do learners need to learn?

Identification of different earthing systems and supplies to enable suitable selection of interfacing equipment. Suitability of supplies for addition of equipment.

1.20 Electrical **circuit types**

Range:

Circuit types - power (radial and ring final circuits), lighting (switching and ELV), control, auxiliary.

What do learners need to learn?

Identification of different types of electrical circuits in line with current building regulations and BS 7671.

1.21 **Methods** used to terminate and connect conductors

Range:

Methods - screwed, crimped, compression connections, soldered, insulation displacement.

What do learners need to learn?

Methods used to terminate and connect conductors using a variety of methods recognised within the industry.

1.22 Broadband and Wi-Fi requirements and how to assess suitability for **interfacing equipment**

Range:

Interfacing equipment - routers, switches, data receivers, smart interfaces.

What do learners need to learn? Communication systems and interfacing equipment used by the installed equipment to monitor/control. Identify the software systems in use.	**Skills** DC1

1.23 Existing systems and implications for new installations

What do learners need to learn?

Implications of installing new equipment into existing installations, and the problems associated with older installation cable types and the installed equipment. With consideration of implications including:

- cable types and sizes.
- electrical accessories and equipment.
- requirements for segregation.
- number of cores and conductors.

1.24 Decommissioning existing systems in preparation for new installations

What do learners need to learn?	Skills
Safe isolation procedures and the risks associated with older installations, including building materials (asbestos). New installations including: • processes to make existing products and systems safe to decommission before installation of new products. Isolating electrical and other relevant services • how to identify potential issues before decommissioning a system.	MC2

System commissioning (Outcome 3)

1.25 Inspections of electrical and electronic equipment before putting into service

What do learners need to learn?	Skills
Processes for inspecting electrical and electronic equipment, associated wiring and documentation required during the process, including manufacturer's instructions, BS 7671 and its model forms when checking correct electrical connections.	EC5

1.26 Testing of electrical and electronic equipment

What do learners need to learn?	Skills
Tests required and where applicable the sequence in which they are performed with reference to BS 7671 and manufacturer's instructions.	EC5

1.27 Adjusting equipment to meet installation standards to ensure correct function

What do learners need to learn?	Skills
To follow manufacturer's information for the setting-up and commissioning of electrical and electronic equipment, including functional testing.	EC5

1.28 Handover of equipment to client

What do learners need to learn?	Skills
Handover procedure to client including records, demonstration, O&M manuals, maintenance requirements and certification.	EC1 EC2 EC3 EC6

System maintenance (Outcome 4)

1.29 Fault-finding **techniques**

Range:

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

What do learners need to learn?	Skills
Logical and systematic process steps in the determination and repair of system faults. Suitable precautionary measures such as safe isolation and anti-static measures.	MC2

1.30 Technology for maintaining, fault-finding and diagnostic work as well as software / firmware updates

What do learners need to learn?
Current fault-finding instruments, information and techniques used to diagnose and rectify system faults.

1.31 Patterns of system failure and requirements for regular maintenance, repair, or replacement

What do learners need to learn?	Skills
Equipment required, with reference to manufacturers data and likely components that may fail. Ensuring that a range of components are held as spares, for each of the systems, including the reasons for doing so including potential reduction of downtime. Checking manufacturer’s software and firmware support, including items no longer supported by system updates. Advising stakeholders on suitable methods for maintaining or updating systems and components.	EC4 EC5 MC2 MC6

1.32 Types of **faults** and their implications

Range:

Faults – open circuit, short circuit, earth fault, insulation fault, equipment failure, undervoltage, overvoltage, EMI.

What do learners need to learn?

The different types of fault that can occur in systems and equipment as ranged. The effects and risks associated with each type of fault and typical causes. Methods used to reduce the potential for each type of fault and how each can be detected.

Outcome 2 - Install electrical and electronic equipment systems

Performance criteria

2.1 Assess risk associated with tasks

What do learners need to learn?

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

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

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

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

Range:

Information - manufacturer's instructions, building regulations, drawings, BS-EN standards, data sheets.

What do learners need to learn?	**Skills**
Identify information in the specification and drawings for the installation, and check that this information against the manufacturer's installation instructions to ensure that all the available information is present for the installation. Ensure that the information obtained is accurate, that it is valid, and that the equipment is suitable for the installation.	EC4 EC5

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

What do learners need to learn?

Select the appropriate hand and power tools to install the electrical and electronic equipment.

Check the information within the manufacturer’s installation instructions to identify if any specialist tools and equipment are needed for the task.

Carrying out a visual inspection of equipment, tools, materials, and resources to ensure that they are fit for purpose.

2.4 Mark out the position of electrical and electronic equipment

What do learners need to learn?	**Skills**
Using the correct measuring and levelling equipment, along with the installation drawings, mark out the position of the equipment.	MC1 MC7

2.5 Analyse situations to identify potential causes of delays and errors

What do learners need to learn?	**Skills**
Identify any possible causes for delay in the installation including installation site not ready, equipment not delivered, lack of experienced qualified installation engineers and ensure that the client is informed of any likely delays.	MC1 MC2

2.6 Think creatively to adapt designs as appropriate

What do learners need to learn?

Identify and consider changes to the installation method, taking into account any change in the installation site or changes to equipment being installed, including where site conditions are different from the information provided.

2.7 Use tools and equipment to carry out tasks

What do learners need to learn?

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

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

2.8 Handle materials

What do learners need to learn?

Handling containment materials and cabling must be carried out safely and in accordance with the Manual Handling Operations Regulations. Ensure that lifting aids are available and have been checked for operation and damage, and that any lifting tackle available is suitable and serviceable.

Ensure all PPE relevant to the handling task is available and worn (gloves and boots).

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

What do learners need to learn?

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

2.10 Connect electrical and electronic equipment to the installed systems

What do learners need to learn?

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

2.11 Install cable and cable containment systems

What do learners need to learn?

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

2.12 Terminate cables and connect conductors

What do learners need to learn?

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

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

2.13 Connect additional components to existing BSE systems

What do learners need to learn?

Make connections to any associated existing BSE systems in the range (see 1.11 - lighting, power, heating, cooling) using current industry techniques and manufacturers information.

2.14 Remove electrical, electronic and mechanical equipment

What do learners need to learn?

Remove and correctly dispose of any redundant materials and systems, ensuring that any recycling is carried out.

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

Outcome 3 - Commission electrical and electronic equipment systems

3.1 Inspect electrical and electronic equipment

What do learners need to learn?

Complete inspections as per relevant electrical inspection schedules used in accordance with BS 7671 and IET Guidance Note 3. Consideration should also be given to O&M manuals and manufacturers data.

3.2 Test electrical and electronic equipment systems

What do learners need to learn?

Testing carried out on electrical systems in accordance with BS 7671 and IET Guidance Note 3 where applicable. Identifying the appropriate instrument for each test to be carried out in terms of:

- the instrument 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

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

Skills
DC1

3.3 Complete required documents for the task

What do learners need to learn?

Explain the purpose of certification and associated documentation and information that must be contained on completion documentation.

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

Skills
EC1
EC3
EC4
EC5

3.4 Analyse and interpret test information and data

What do learners need to learn?	**Skills**
Analyse and interpret information from various digital and non-digital sources (instrumentation, log files, read-outs).	MC6 DC1 DC4 MC1

3.5 Identify inadequate installations

What do learners need to learn?	**Skills**
Compare results against the design criteria, manufacturers data and relevant British Standards, and check suitability. Where inadequate results are confirmed, client and manufacturers would need to be informed.	EC1 EC6 MC2 MC6 DC4

3.6 Setup connection including network and router

What do learners need to learn?
Setting-up of routers and hubs to enable Wi-Fi - follow system instructions to network equipment, either hard wired or wireless.

3.7 Review performance in relation to customer network

What do learners need to learn?	**Skills**
Use apps to check the speed of the internet using the customers' network. Desired/Optimum speeds should be detailed in any manufacturer's data.	EC5 DC4 DC5 DC6

3.8 Demonstrate product and present information to customer

What do learners need to learn?	**Skills**
Operate the system and complete a full report on the system. Use the manufacturer's information and instructions to demonstrate that installed equipment is functioning correctly and within any limits/tolerances. Detail the energy-saving practices that should be followed. To include suggesting switching equipment off instead of leaving on standby.	EC1 EC2 EC3 EC4 EC5 EC6 MC8 DC3

Use energy-efficient lighting such as LEDs. Ensure registration of the equipment is carried out with the manufacturer where equipment is under warranty.	

Outcome 4 - Maintain electrical and electronic equipment systems

4.1 Communicate health and safety risks to stakeholders orally

What do learners need to learn?	**Skills**
Communicate with stakeholders in line with system maintenance for example explaining unsafe situations and the risks associated with them. Communications may relate to the production of a risk assessment for maintenance activities, explaining relevant content of the risk assessment to stakeholders.	EC1 EC2 EC3 EC4 EC5 EC6

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

What do learners need to learn?
Follow correct sequence of activities to complete 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

4.3 Allocate time and resources to complete tasks including materials required

What do learners need to learn?	**Skills**
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	MC1 MC2

Liaise with stakeholders to agree timings to minimise disruption and enhance safety.	

4.4 Collect system data from ICT applications and other **sources**

Range:

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

What do learners need to learn?	**Skills**
ICT, including use of computers, digital transmission over IP, email, mobile communication technology, for the collection of data and completion of work sheets/maintenance sheets.	DC1 DC2 DC3 DC5

4.5 Record system data

What do learners need to learn?	**Skills**
System data may include work records or equipment maintenance sheets etc. Familiarity with records of work, including preventative maintenance and reactive maintenance requirements. Inspection and test schedules maybe company or system specific, so awareness is required of documentation to be completed for maintenance activities.	EC1 EC3 EC4

4.6 Test equipment to ensure it is safe to work on

What do learners need to learn?
Check to ensure safe isolation has been carried out correctly and that any stored charge within the equipment has been discharged.

4.7 Inspect, test and analyse information to identify potential faults

What do learners need to learn?	**Skills**
Inspect for potential faults on system components through visual inspection of system, operational checks, feedback from system users, and performance testing to gather information to be used as part of analysis of situation, checking software for corruption, viruses, End of Life (EoL) . Collate all available information and analyse regarding any possible or potential faults.	EC4 EC5 MC2 MC6 DC4 DC5

Reference to be made to manufacturer's instructions or specifications (fault-finding flow chart or detailed procedure). Check system performance criteria for correct settings, readings, or maximum/minimum permitted standards. Analyse conditions that affect suitability of systems such as alterations to building, structure or equipment.	

4.8 Think creatively to propose solutions for system faults

What do learners need to learn?	**Skills**
Using analysis, develop strategic, economic and practical methods for rectifying identified possible or potential faults. System faults and issues include deteriorating or outdated equipment over time and having contingency plans in place for equipment that is no longer manufactured or supported. 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 several reasons. Contingency budget planning needs to be reviewed regularly with consideration given to performance levels of existing equipment and plant.	MC2 MC7 MC10

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

What do learners need to learn?	**Skills**
Communicate with stakeholders and obtain necessary permissions to rectify faults, prolong potential faults or improve systems for changing conditions. 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 DC6

4.10 Replace components or update software

What do learners need to learn?

Replace components or update software within a system as necessary to meet industry and task - specific requirements. Consideration should be given to safe/appropriate disposal of replaced components and ensuring all work has been recorded or records of work updated, including O&M manuals.

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 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 IT resources

Guidance for delivery

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

Formative assessment – oral Q&A, SmartScreen worksheets (samples available), observation of measuring activities:

  - Practical – use of pre-set formative 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 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 Wiring 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 – Electrical and electronic equipment engineering

The electrical and electronic equipment engineering occupational specialism is assessed by one practical assignment. The duration of the assessment is 16 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 complete the given installation tasks successfully. Shows the technical skills to use tools and materials safely, and in a logical order. Displays knowledge and understanding in relation to the planning and design of systems as well as the ability to modify existing systems to accommodate equipment and technologies.
Task 2 - Install, commission and decommission	Working in a safe manner, carrying out inspection and testing and interpreting test results, use of tools and equipment, use of diagnostic equipment, working with documentation (manufactures instructions, technical regulations and building regulations), carrying out tasks in clear and logical sequence, carrying out clear record keeping of test result and setting up and commissioning systems for intended use. Providing clear and effective information on product use and care to clients.
Task 3 – Carry out maintenance activity	Applying knowledge and understanding through practical skills to solve a particular scenario/problem. Analysing data and justifying decisions/approaches taken e.g. materials, techniques, appropriate protection of customer property and effective use of materials, consideration of costs and impacts to environment. Following safe systems and procedures and providing clear technical and non-technical advice.

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 electrical and electronic equipment systems (39%)	T1 Planning the installation	Health and Safety	Assessment of risk, PPE, working safely
		Design and planning	Method statement, materials and product list, circuit diagrams, measuring and marking out
	T2 Installation and commissioning	Systems and components	Using tools and equipment, positioning and securing components
	T1 Planning the installation	Reports and information	Interpretation of drawings, specifications, manufacturer instructions
PO3 Commission electrical and electronic equipment systems (34%)	T1 Planning the installation	Health and Safety	Assessment of risk, PPE, working safely
	T2 Installation and commissioning	Systems and components	Using tools and equipment, positioning and securing components
		Reports and information	Certification and schedules, completion of basic O&M manual, statement relating disposal of equipment
		Inspection and testing	Inspection and testing checks, measuring of wiring and components, installation of wiring and components

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***
		Handover and communication	Handover to customer
PO4 Maintain electrical and electronic equipment systems (27%)	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 Replace components, use of tools Completed documentation Communication with customer to diagnose fault Fault diagnosis, fault rectification

353 Electrotechnical engineering

Level:	3
GLH:	650
Assessment method:	Practical assignment

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 develop their knowledge, understanding 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

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

- 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?

Underpinning knowledge outcome

On completion of this specialism, learners will understand:

1. Electrotechnical engineering knowledge criteria

Performance outcomes

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

2. Install electrotechnical systems
3. Commission electrotechnical systems
4. Maintain electrotechnical systems
5. Decommission electrotechnical systems

Completion of this specialism will give learners the opportunity to develop their maths, English and digital Skills.

Specialism content

Outcome 1

Common knowledge criteria

Tools, equipment and materials

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

Range:

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

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

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

What do learners need to learn?

Tools required related to the requirements of the job specification – identification of the range of both general and specific tools required. Select 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.

1.2 Operation and handling requirements

What do learners need to learn?

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.

Electrical installations

1.3 Principles of electrical **circuits** and **loads**

Range:

Circuits – ring-final, radial, lighting, series, parallel, AC, DC, magnetic effect, temperature effect, voltage drop, single phase, three phase.

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

What do learners need to learn?	**Skills**
How different circuit arrangements affect voltage and current behaviour. Control of loads by circuit arrangement and the reasons why particular circuit arrangements are selected. 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 load affect current and voltage including resistive, inductive, and capacitive loads. How power factor is induced and how it changes circuit properties such as current, voltage and power. Methods used to reduce power factor.	MC5 MC6

1.4 Assessment of general characteristics outlined in national standards

What do learners need to learn?	**Skills**
Assessing general characteristics of installations such as supply types, and earthing arrangements such as TT, TN-S and TN-C-S. Determining maximum demands with application of diversity. How external influences affect installation design, selection and erection. Taking maintainability into account when designing and certificating installation work.	EC5

1.5 Application of the fundamental principles of national standards

What do learners need to learn?	**Skills**
Refer to the national standards and the requirements of the Electricity at Work Regulations, building regulations and BS 7671 for the design, installation, inspection and testing of electrical systems and equipment. Interpret and implement fundamental principles of BS 7671 including how they are detailed in Parts 4-6 of the standard. Use of information in the Appendices of BS 7671 and Guidance Notes to formulate installation design and protection, giving consideration to the fundamental principles.	EC5

1.6 Special installations and locations specified in national standards

What do learners need to learn?	**Skills**
Refer to Part 7 of the latest edition of the requirements for electrical installation (BS 7671:2018 – Requirements for Electrical Installations, IET Wiring Regulations) and IET Guidance Notes 1–8 for information and support for electrotechnical activities within special locations as specified in the national standards. This includes identifying installations where specialist activities may be beyond the competency of non-specialist operatives.	EC5

1.7 Design concepts of installations specified in national standards

What do learners need to learn?	**Skills**
Refer to the latest edition of the requirements for electrical installation (BS 7671:2018 – 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

1.8 Methods of selecting and installing wiring systems

What do learners need to learn?

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 and auxiliary.

1.9 Methods of selecting and erecting electrical installation components

What do learners need to learn?

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.

1.10 Types of lighting and luminaire

What do learners need to learn?

Application of different lighting, lamp types and luminaires used for different effects including efficacy, energy efficiency, lumens, regulatory lux levels and colour rendering.

How height and spacing of luminaires affect illumination values.

Specific knowledge criteria for performance outcomes

System installation (Outcome 2)

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

Range:

Cable installation and wiring system supports - single and multicore thermoplastic cable, SWA multicore armoured cable, MICC, FP200- Fire resistant cable, flexible cable, data cable CAT5/6, cable tray, cable conduit (steel and PVC), cable trunking, ladder racking, cable basket, cable cleats, clips, cable hangers.

What do learners need to learn?

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.

1.12 Methods of **terminating** cables

Range:

Terminating - cable glands, grips, clamps.

What do learners need to learn?

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.

1.13 Methods of **terminating and connecting** conductors

Range:

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

What do learners need to learn?

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

When securing terminations/connections consideration should be given to building regulations, manufactures instructions and British Standards.

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

Appropriate methods should be selected depending on the type of maintenance expected including access.

System commissioning (Outcome 3)

1.14 Inspections for initial verification of electrotechnical systems

What do learners need to learn?

Standard procedures and processes to undertake inspections, including the items to be inspected when carrying out initial verification in accordance with BS 7671 and IET Guidance Note 3. Consideration should also be given to providing the required information including O&M manuals.

1.15 Testing for electrotechnical systems

What do learners need to learn?

Tests to be carried out on electrical installations in accordance with BS 7671 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 and IET Guidance Note 3.

Skills
DC1
DC5
DC6

1.16 Equipment adjustments as required by installation standards to ensure correct function

What do learners need to learn?

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.

System maintenance (Outcome 4)

1.17 Types of electrotechnical **system maintenance**

Range:
System maintenance - planned and preventative maintenance (PPM), reactive maintenance.

What do learners need to learn?

Legal requirements relating to PPM, responsibilities for undertaking maintenance regimes.
Advantages and limitations of PPM and reactive maintenance.
Requirements for completing documentation and updating O&M manuals.

1.18 **Fault-finding** and **rectification techniques**

Range:

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

Rectification techniques - repair, replace, adjust.

What do learners need to learn?	**Skills**
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.	MC2

1.19 Maintenance requirements for different **building types** and locations

Range:

Building types - private, commercial, house in multiple occupation (HMO), residential.

What do learners need to learn?

Regulations concerning set systems to put in place in relation to different types of premises.

Some types of buildings (hospitals, chemical plants, paint stores) are covered by specific, specialist regulations and control measures.

1.20 Maintenance of older systems and installations

What do learners need to learn?

Identification of older systems that may not be compliant with current regulations and reporting on condition and suitability for continued use.

System decommissioning (Outcome 5)

1.21 Ways of making systems safe to decommission

What do learners need to learn?

Isolate system from the supply source or outgoing service, turn off the electrical supply.

Handle materials to protect their integrity and safety during decommissioning.

Remove pre-installed components from electrical installations.

Reconfigure electrical installations during the decommissioning process.

Categorise waste produced during the decommissioning process.

Use construction materials to make good the building fabric following installation component removal.

1.22 Methods of identifying potential issues before decommissioning systems

What do learners need to learn?

Methods including reviewing O&M manuals, and consultation of component data sheets and drawings. Benefits of devising a timely plan when decommissioning systems.

Outcome 2 - Install electrotechnical systems

Performance criteria

2.1 Assess risk associated with tasks

What do learners need to learn?

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

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

Consideration should be given to recording of risk assessment findings in line with regulations as well as the responsibilities of employees versus employers.

2.2 Collect and collate **information** required to complete tasks

Range

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

What do learners need to learn?	**Skills**
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.	EC4 EC5 MC4

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

Range:

Tasks - installing wiring, containment systems and connecting equipment.

What do learners need to learn?
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.

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

Range:

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

What do learners need to learn?	**Skills**
Design installations in accordance with BS 7671 and guidance notes. Installation circuits and protection suitable for current carrying capacity, voltage drop limitations, earth fault paths, earth fault loop impedance values and maximum values, selection of protective devices based on data and load conditions, protective conductor selection based on data such as thermal constraints and installation conditions.	MC1 EC1 EC2 MC7 DC2

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

What do learners need to learn?	**Skills**
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

2.6 Analyse situations to identify potential causes of delays and errors

What do learners need to learn?	**Skills**
Delays and errors may include the work site not being ready, having incorrect drawings, insufficient materials etc. Learners should review available progress plans such as Gantt charts/critical path analysis tracking, as well as site meetings to discuss progress detailing any causes for concerns.	EC5

2.7 Mark out the position of electrical equipment

What do learners need to learn?	Skills
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

2.8 Use tools, equipment and materials to carry out tasks

What do learners need to learn?
Setting up and using the correct hand and power tools, plant and equipment required to complete work activities, taking into consideration safe use of the equipment and suitability of tools and equipment, including suitable PPE, matched to specific tasks.

2.9 Install cable containment systems

What do learners need to learn?	Skills
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

2.10 Install cabling

What do learners need to learn?

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

2.11 Connect electrical equipment to installed wiring systems

What do learners need to learn?

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

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

2.12 Terminate cables and connect conductors

What do learners need to learn?

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.

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

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

What do learners need to learn?

Use of measuring and monitoring equipment to determine and analyse different types of load and the effects of load on circuit conditions such as current and voltage. Analyse power factor and determine suitable measures to minimise impact of reactance on circuit conditions.

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

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

What do learners need to learn?

Select suitable types of lighting lamp and luminaire for given conditions such as intended use and location. Consider factors affecting selection such as space-height ratio, manufacturers' photometric data, conditions of evacuation, energy efficiency, colour rendering.

Outcome 3 - Commission electrotechnical systems

3.1 Prepare for inspection, testing and commissioning

What do learners need to learn?

Gather the information necessary for detailed inspection, testing and commissioning of electrical installations, including manufacturer's data, design information, tolerances, drawings and charts.

Skills
MC1
MC4

3.2 Inspect electrotechnical systems

What do learners need to learn?

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

3.3 Test electrotechnical systems

What do learners need to learn?

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

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

- ensuring the instrument is fit for purpose
- identifying the correct scale or setting

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

Skills
DC1

3.4 Analyse and interpret information and data

What do learners need to learn?

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.

Skills
MC6
MC7
DC1
DC4
DC5

3.5 Complete commissioning **documentation**

Range:

Documentation - Electrical Installation Certificate, Minor Electrical Installation Works Certificate, schedule of inspections, schedule of test results.

What do learners need to learn?	**Skills**
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. Ensure O&M manuals are complete and reflect the 'as fitted' work undertaken. Handover information to stakeholders.	EC1 EC3 EC4 EC5

Outcome 4 - Maintain electrotechnical systems

4.1 Communicate health and safety risks to stakeholders orally

What do learners need to learn?	Skills
Communicate with stakeholders in line with system maintenance undertaken. This includes 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

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

What do learners need to learn?

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

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

What do learners need to learn?	Skills
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

4.4 Collect and record electrical installation data

What do learners need to learn?	Skills
Collect relevant electrical installation data. Electrical installation data may include work records or equipment maintenance sheets. Familiarity with records of work, including preventative maintenance and reactive maintenance requirements. Inspection and test schedules may be company or system specific, so awareness needed of documentation to be completed for maintenance activities.	DC1 DC4 EC1 EC2 MC1 MC4 MC7

4.5 Analyse data from work activity

What do learners need to learn?	Skills
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

4.6 Provide technical advice and guidance to technical and non-technical stakeholders

What do learners need to learn?	Skills
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

4.7 Test electrical installation to ensure it is safe to work on

What do learners need to learn?
Check to ensure safe isolation has been carried out correctly and that any stored charge within the equipment has been discharged.

4.8 Analyse information to identify potential faults

What do learners need to learn?	Skills
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

4.9 Think creatively to propose solutions for installation faults

What do learners need to learn?	Skills
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

4.10 Replace **components** of electrotechnical systems

Range:

Components - lamps, tubes, accessories, wiring, containment, devices

What do learners need to learn?
Replace components within an electrical installation as necessary to meet industry and task specific requirements. 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

5.1 Communicate with relevant stakeholders to ensure required information is available to undertake the task using electronic communication

What do learners need to learn?	Skills
Systems used in the tracking and monitoring of site/contract progress. This includes software packages (word processing, email, spreadsheets).	EC1 EC2

5.2 Make systems safe to work on including safe and secure isolation and discharging stored charge

What do learners need to learn?	Skills
Carry out safe isolation procedures and ensure that the electrical installations is discharged before commencing work on decommissioning.	MC7

5.3 Remove electrotechnical systems

What do learners need to learn?

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 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 IT resources

Guidance for delivery

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

Formative assessment – oral Q&A, SmartScreen worksheets (samples available), observation of measuring activities:

  - Practical – use of pre-set formative 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 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 percentage (%) ***Defined by IfATE and covers broad K&S of an OS***	**Task** ***The specific instructions for candidates to provide evidence for***	**Assessment Theme** ***The themes markers are judging the evidence on for OC***	***Typical evidence to be marked***
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	Assessment of risk, PPE, working safely Repair/replacement of components, use of tools Documentation completion Communication with customer to diagnose fault

Performance Outcome and percentage (%) ***Defined by IfATE and covers broad K&S of an OS***	**Task** ***The specific instructions for candidates to provide evidence for***	**Assessment Theme** ***The themes markers are judging the evidence on for OC***	***Typical evidence to be marked***
		Handover and communication Working with faults	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

354 Gas engineering

Level:	3
GLH:	650
Assessment method:	Practical assignment

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 develop their knowledge and understanding of, and skills in:

- Fundamental safe working practices associated with gas engineering
- Tools and equipment associated with the installation of gas systems
- Installation, maintenance, repair and service requirements of gas systems and appliances
- Scientific principles used in gas engineering
- Measuring and marking of components and pipework

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

- What does a gas engineer do?
- What tools and equipment do gas engineers use as part of their role?
- What are the steps required to become a qualified gas engineer?

Underpinning knowledge 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:
2. Install gas systems
3. Commission gas systems
4. Maintain gas systems
5. Decommission gas systems

Completion of this specialism will give learners the opportunity to develop their maths, English and digital skills.

Specialism content

Outcome 1

Common knowledge criteria

Health and safety

1.1 **Typical hazards** and risks associated with working with gas systems

Range:

Typical hazards - asbestos, explosions, carbon monoxide poisoning, slips and trips, manual handling, working at height, burns, dust, electrocution.

What do learners need to learn?

The different hazards associated with working with gas systems and how to negate the risks.

1.2 Safe working practices associated with working with gas systems

What do learners need to learn?	Skills
Safe working practices associated with working with gas systems including building regulations, documents (risk assessments and method statements) and PPE.	EC3 EC5

1.3 Emergency procedures for **unsafe situations**

Range:

Emergency procedures - Gas Industry Rights of Entry Regulations, Gas Industry Unsafe Situations Procedure.

Unsafe situations - gas escapes, explosions, carbon monoxide.

What do learners need to learn?	Skills
The unsafe situations that that may occur in the workplace. The correct procedures and reference documents to use if they do arise. When unsafe situations need to be reported with consideration given to the, Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR).	EC5

Tools, equipment and materials

1.4 Types of **tools** and **equipment, and** materials

Range:

Tools and equipment - 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.

What do learners need to learn?

Tools, equipment and materials, their correct method of use and when they should be used, for access and measuring when working on gas systems.

The characteristics and properties of different tools, equipment and materials and what makes them suitable for different tasks.

1.5 Operation and handling requirements of **tools, equipment** and materials

Range:

Tools and equipment - pressure gauges, combustion performance analyser, leak detector, temporary continuity bonds.

What do learners need to learn?

How tools, equipment and materials are maintained and stored to minimise damage and maximise longevity.

The processes for maintaining and re-calibrating equipment, and the implications of not following these processes correctly.

Gas systems

1.6 Types of **components** and their suitability for different **appliances** and types of **systems**

Range:
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 m3/h), heat pumps, hydrogen boilers.

Systems - natural gas (NG), liquefied petroleum gas (LPG).

What do learners need to learn?	Skills
The requirements of different components and their suitability for different systems, including: • purpose • sequence of operations • appliance type Reference to manufacturer's instructions	EC5

1.7 How **components** operate within a system/appliance and integrate to enable the system to operate effectively

Range:
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 m3/h).

What do learners need to learn?

Components within a gas appliance/system, how they interact with each other to control the temperature of heated water, operational periods and safe combustion of the gas.

1.8 **Factors** that affect the choice and suitability of components included in a system

Range:

Factors - Location, gas type, appliance type, size, independent certification/approval (CE marking), legislation, environmental/ efficiency.

What do learners need to learn? Characteristics of components in a system and how these affect choice and suitability.

1.9 Waste and **waste products**

Range:

Waste products - magnetite, corrosion smells, bacteria.

What do learners need to learn? 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.

1.10 **Safety devices** applicable to gas systems, their characteristics and operation

Range:

Safety devices - carbon monoxide detectors, under pressure shut off valves (UPSO), over pressure shut off valves (OPSO), safety shut off valves (SSOV), emergency control valves (ECV), air pressure switches, low water pressure switches, thermostats, flame supervision devices.

What do learners need to learn? Safety devices used in gas systems/appliances, their testing procedures and how to replace if faulty to ensure safe use of the appliance/system.	**Skills** MC2

1.11 Gas and the combustion process

What do learners need to learn?

The combustion process and analysis including complete and incomplete combustion, the by-products (carbon dioxide (CO2) levels, carbon monoxide (CO) levels oxygen (O2) levels) of combustion and their trigger values.

Types of burners (simplex and duplex) and interaction with other devices. 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

1.12 Mechanical heat ventilation recovery (MHVR)

What do learners need to learn?

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.

1.13 Types of chimneys and chimney systems in relation **to gas appliance types**

Range:

Gas appliance types - open flued (type B appliances), room sealed (type C appliances), flueless (type A appliances).

What do learners need to learn?

The fundamental operating principles of the various chimneys and chimney systems, their testing requirements and their suitability for different appliances types.

1.14 **Types of ventilation** in relation to gas

Range:

Types of ventilation - permanently open, closeable, flyscreen, terracotta, unsleeved, incomplete, cooling air, high/low level ventilation, compartment ventilation, 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, ventilation through two or more rooms, mechanical ventilation.

What do learners need to learn?	**Skills**
The types of ventilation and their requirements for each fuel, flue type and appliance. Calculations of ventilation.	MC2

1.15 Types of **gas appliances** and their system requirements

Range:
Gas appliances - water heaters, central heating boilers, space heaters, cookers, gas meters (≤ 6 m^3/h).

What do learners need to learn?

Different gas burning appliances and their system requirements.

Gas engineering science

1.16 **Scientific principles** and **concepts** as applied to gas engineering

Range:
Scientific principles - complete combustion, incomplete combustion, stoichiometric combustion, fuels, chemical, smouldering, diffusion, rapid, spontaneous, explosive.

Concepts - ventilation, flue draft, fuels.

What do learners need to learn?

Scientific principles of combustion and the effects these can have on the combustion process.

Pipework technology

1.17 Types of **pipework**

Range:
Pipework - copper pipework, steel pipework, pliable corrugated (stainless steel) pipework, polyethylene (PE) pipework.

What do learners need to learn?

Characteristics of different types of pipework, including prefabricated and modularised components and distribution systems, different sizes, types of materials, their suitability for different situations, and tools and equipment (including fixings) required.

Fittings and components and their use for different piping scenarios. The types of fixings available for the different materials.

1.18 Flow rates and their relationship to pipework and system design

What do learners need to learn?

Different pipework materials, fittings and components and their effects on pressure and flow of the gas. The detrimental effect that pressure loss can have on the combustion of gas if too large.

1.19 Different **techniques** for forming and bending pipework

Range:
Techniques - bending machine, bending spring.

What do learners need to learn?

The different techniques for forming and bending pipework and how these are applied during the installation of gas systems/appliances.

Legislation and industry guidance

1.20 Implications of legislation, **standards and manufacturer's instructions** alongside additional **guidance** to employers and those working with gas systems

Range:

Legislation, standards and manufacturer's instructions - Gas Safety (Installation and Use) Regulations, Gas Industry Unsafe Situations Procedure, Gas Safety Rights of Entry Regulations, Institution of Gas Engineers and Managers (IGEM) Standards, British Standards, Building Regulations, Manufacturer's Instructions.

Guidance - Gas Safe Register Technical Bulletins.

What do learners need to learn?	**Skills**
Legislation standards and manufacturer's instructions alongside additional guidance for installation of systems and the implications of these for employers and end users.	EC5

Building technology

1.21 Types of **fixtures** and suitability for different **building fabrics**

Range:

Fixtures - screws, nails, solid wall fixings, plasterboard fixings, security bolts.

Building fabrics - block walls, brick walls, wooden partitions, plasterboard walls.

What do learners need to learn?

The various types of fixings, and their suitability for different building materials.

Specific knowledge criteria for performance outcomes

System installation (Outcome 2)

1.22 Bending techniques

Range:

Bending techniques - hand bending machine, spring.

What do learners need to learn?

Types of bending techniques and the different tasks these may be used for.

1.23 Connection techniques

Range:

Connection techniques - threading, soldering, compression, press-fit, PTFE, jointing compound.

What do learners need to learn?

Types of jointing methods and processes and how to transition from one pipework material to another.

Soldering must be lead-free in all applications.

System commissioning (Outcome 3)

1.24 **Inspection techniques** and how they are applied in commissioning systems

Range:

Inspection techniques - visual inspection.

What do learners need to learn? The factors to inspect during a visual inspection in line with manufacturer's instructions.	**Skills** EC5

1.25 **Factors** to inspect during commissioning, and how expected standards are defined

Range:
Factors - 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.

What do learners need to learn?	Skills
Factors to inspect during commissioning. 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

1.26 **Testing** of installation

Range:
Testing - tightness test, flue flow test, spillage test, room sealed appliance (case seals) test.

What do learners need to learn?

Critical testing that needs to be completed as part of installation and commissioning.

1.27 Safe storage and supply of **fuel source**

Range:
Safe storage – LPG cylinders, LPG bulk tanks.
Fuel source - natural gas (NG), liquefied petroleum gas (LPG).

What do learners need to learn?

The safe storage and safe supply of NG and LPG.

System maintenance (Outcome 4)

1.28 Cleaning of components without compromising the system and associated tools, equipment and materials

What do learners need to learn?	Skills
Cleaning and servicing with consideration given to appropriate, techniques, tools and processes in line with manufacturer’s recommendations and servicing schedules.	EC5

1.29 **Fault-finding techniques,** their suitability for different situations and how they are applied in practice

Range:

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.

What do learners need to learn?	Skills
The process for carrying out fault-finding techniques and which techniques are suitable for different situations and how planned maintenance activities can minimise faults.	EC5 MC2 DC1 DC5

Decommissioning (Outcome 5)

1.30 Procedures involved in decommissioning

What do learners need to learn?
The processes and procedures involved in decommissioning gas systems.

1.31 Requirements for recording, labelling and reporting decommissioned systems

What do learners need to learn?	**Skills**
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 gas systems

Performance criteria

2.1 Interpret information from a risk assessment

What do learners need to learn?	**Skills**
Review and interpret risk assessments following HSE guidance. Consideration of employee’s versus employer’s responsibilities in relation to risk assessment completion.	EC4 EC5

2.2 Use **tools** in accordance with good working practice

Range:
Tools - 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.

What do learners need to learn?

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.

2.3 Install **pipework** relevant to the **type of gas** being conveyed

Range:
Pipework - copper pipework/fittings, steel pipework/fittings, pliable corrugated (stainless steel) pipework/fittings.

Type of gas - Natural gas (NG), Liquefied petroleum gas (LPG).

What do learners need to learn?	**Skills**
Install gas pipework within or on the building fabric in line with industry standards, building regulations and safe working practices.	MC1

2.4 Install **clips/brackets** to various **substrates**

Range:
Clips/Brackets - nail-on clip, plastic stand-off, brass Munson ring, steel Munson ring, meter brackets, flue brackets.

Substrates – wood, brick/block, plasterboard.

What do learners need to learn?	**Skills**
Fix clips and brackets at recommended spacing intervals to meet the specification requirements and in line with current industry standards.	MC1

2.5 Install **flues**/chimneys to facilitate a range of **gas appliances** and equipment

Range:
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).

What do learners need to learn?	**Skills**
Install a selection of flue types to different locations in line with gas and building regulations and manufacturer's instructions, including the use of terminal guards as required.	MC1

2.6 Install ventilators to facilitate the correct combustible air requirements for **appliances** installed in a variety of **locations/buildings**

Range:
Appliances - space heater, boiler, water heater, gas cooker.
Locations/buildings - cavity walls, high level, low level, through two or more rooms.

What do learners need to learn?	**Skills**
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.	MC1

2.7 Install **appliances**

Range:
Appliances - space heater, boiler, water heater, cooker.

What do learners need to learn? Install gas appliances in line with manufacturer's instructions, following all installation instructions.	**Skills** MC1

2.8 Install **components** into appliances

Range:
Components - multi-functional control valve/ gas valve, fan, burner, pressure relief valve, automatic air vent, printed circuit board, air pressure switch.

What do learners need to learn?

Install a range of components into gas appliances.

2.9 Install **controls** into systems

Range:
Controls - programmer, room thermostat, cylinder thermostat.

What do learners need to learn? Install control components into a central heating system.	**Skills** DC6

2.10 Install **thermal insulation materials**

Range:
Thermal insulation materials - polyisocyanurate foam pipework insulation, nitrile rubber pipework insulation, polyethylene foam pipework insulation.

What do learners need to learn?

Install various thermal insulation to prevent the freezing of system pipework.

2.11 Install **seals** appropriate to the gas **appliance**

Range:
Seals - combustion chamber/burner seals, gas seals, water seals.

Appliances - space heater, boiler, water heater, cooker.

What do learners need to learn?
Check the condition of and replace different types of seal found in a gas appliance from a selection of seals.

2.12 Check **gas components** are in accordance with **design parameters**

Range:
Gas components - thermistors, air/gas ratio control valves, thermostats, combustion performance analysis, gas valves.

Design parameters - resistance readings, pressure settings, temperature range, acceptable levels, manufacturer's parameters.

What do learners need to learn?	**Skills**
Use recognised testing methods (multimeters, gas rating, gas pressure testing, etc) to ensure all components are within design parameters.	MC1 MC2 EC5

2.13 Check gas components are suitably certified

What do learners need to learn?	**Skills**
Check that gas components comply with manufacturer's requirements and are suitably certified (CE marking).	EC5

2.14 Analyse information to identify **requirements** for gas installation

Range:
Requirements - flueing requirements, ventilation requirements, pipe sizing requirements, heat output requirements.

What do learners need to learn?	**Skills**
Analyse customer requirements to identify the size of gas pipework and appliances to meet possible demand.	EC5 MC2

2.15 Communicate **system requirements** to allied trades

Range:
System requirements - electrical control requirements, hot and cold pipework layout, heating system pipework layout.

What do learners need to learn?	**Skills**
Identify and communicate with other trades, detailing timescales and other system requirements.	EC1 EC2 EC6

2.16 Establish **safe working environment** to conduct gas installation

Range:
Safe working environment - well ventilated area, no ignition sources, good housekeeping, temporary removal of meter, use of a temporary continuity bond, liaise with end user.

What do learners need to learn?

Create a safe and clean working environment when installing gas systems and appliances, (housekeeping).

2.17 Ensure no ingress of foreign objects within gas system and component

What do learners need to learn?

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.

2.18 Update relevant line diagrams/installation plans

What do learners need to learn?	**Skills**
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

2.19 Complete a method statement for installation and identifying any potential delays

What do learners need to learn?	Skills
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

2.20 Adapt onsite specific gas system installation changes

What do learners need to learn?

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

2.21 Gather relevant gas system component part **information**

Range:
Information - manufacturer's instructions, normative documents, trade magazines, merchants.

What do learners need to learn?	Skills
Gather relevant documentation for working with gas systems and appliances.	EC5 EC6

2.22 Update digital building information management system **software**

What do learners need to learn?	Skills
Refer to and update digital building information management system software.	DC1 DC2 DC3 DC5 DC6

Outcome 3 - Commission gas systems

3.1 Assess **risks** associated with completing activities

Range:
Risks - explosive atmosphere, carbon Monoxide production, slips, trips and falls, crushing injuries, burns, cuts.

What do learners need to learn?	Skills
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 employee's versus employers.	EC1 EC2 EC3 EC4

3.2 Test all gas rates and **pressures** are within regulatory requirements

Range:
Pressures – operating pressure at the meter or regulator outlet where no meter installed (e.g. LPG), operating pressure at the appliance.

What do learners need to learn?	Skills
Use recognised procedures to calculate the various gas rates and pressures required as well as the gas rate of the appliance. Complete a gas rate and undertake gas pressures.	MC1 MC2 EC5

3.3 Ensure any tools/**equipment** are calibrated correctly

Range:
Equipment – electronic combustion performance analyser, electronic pressure gauge

What do learners need to learn? Calibrate tools and equipment correctly. Consider requirements of electronic testing equipment and check if calibration is required. Calibration certificates.	**Skills** EC5

3.4 Calculate correct purge volumes in accordance with gas installation

What do learners need to learn? Calculate purge volume and purge requirements, including calculating purge requirements to air, calculating purge requirements to burn.	**Skills** MC1 MC2

3.5 Purge system correctly

What do learners need to learn? Complete a safe purge of a gas installation to all industry standards.

3.6 Visually inspect installation to ensure compliance with Gas Safety (Installation and Use) Regulations and appropriate standards

What do learners need to learn?	**Skills**
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

3.7 Complete gas system **handover documentation** to end user

Range:

Handover documentation - manufacturer’s commissioning paperwork, industry recognised forms (Gas Safety Records, Testing and Purging Form), job sheet

What do learners need to learn?	**Skills**
Commission gas appliance/system and complete all commissioning documentation as required by the gas sector.	EC1 EC2 EC3 EC4 EC6 DC1

3.8 Demonstrate safe operation of gas appliance and controls to the end user

What do learners need to learn?	**Skills**
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

3.9 Visually check gas system installation conforms to original design requirements

What do learners need to learn?
Complete a visual check of gas system installation during handover/commissioning to the original system design as well as manufacturer's/regulatory requirements.

3.10 Set gas system parameters to commission in accordance with manufacturer's instructions, appropriate standards and Gas Safety and Use Regulations

What do learners need to learn?	**Skills**
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

3.11 Record commissioning results

What do learners need to learn?	**Skills**
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

3.12 Analyse commissioning results to determine correct gas installation in accordance with original design

What do learners need to learn?	Skills
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

4.1 Question end user to identify any **user concerns**

Range:

User concerns - risk assessments, smell of gas, carbon monoxide alarm sounding, using too much gas, appliance/system not working as intended, gas escapes / water leaks, noise.

What do learners need to learn?	**Skills**
Discuss maintenance requirements with end user /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 to overcome as well as to costs, sustainability and timescales.	EC1 EC2 EC3 EC4 EC5 EC6 MC2 MC6

4.2 Identify the correct replacement **parts** relevant to the appliance from a selection of similar parts

Range:

Parts - multi-functional control valve, fan, burner, pump, plate to plate heat exchanger, main heat exchanger, automatic air vent, diverter valve/cartridge, pressure relief valve, printed circuit board.

What do learners need to learn?
Select the correct replacement part from a selection of similar replacement parts to be fitted to a gas appliance/system. .

4.3 Calculate maintenance downtime

What do learners need to learn?	Skills
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

4.4 Safe handling of all **gas components** when conducting maintenance

Range:

Gas components - smart meters, pre-payment meters, fragile components, dangerous components.

What do learners need to learn?

Handle gas components carefully when conducting maintenance. In addition, the learner is also to be made aware of the possible injuries that may be sustained while working on gas systems/appliances.

4.5 **Identify** potential gas installation system defects and follow unsafe situations procedure, as required

Range:

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.

What do learners need to learn?

Identify a range of potential gas installation system errors and take the correct steps to ensure these are rectified following the unsafe situations procedure.

4.6 Test system in accordance with end user requirements and **appliance type**

Range:

Test - combustion performance analysis, 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).

What do learners need to learn?

Complete critical testing of gas appliance/installations to ensure safety and compliance with end user requirements.

4.7 Remove and replace **faulty gas system components**

Range:

Faulty gas system components - meter regulator, air/gas ratio control valve, multi-functional control valve, burner, thermistor, thermostats, flame supervision devices, printed circuit board.

What do learners need to learn?

Identify faulty gas system parts and components and remove and replace faulty component with new components in accordance with manufacturer's instructions.

4.8 Repair faulty gas system components

What do learners need to learn?

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

5.1 Enable control mechanism from a risk assessment prior to working

What do learners need to learn?

Complete safe and verified isolation of gas, electricity and water supplies prior to commencing work on gas systems/appliances, including the use of isolation locks and 'Do not turn on' information signs.

5.2 Establish consumer needs when decommissioning any gas installation

What do learners need to learn?	**Skills**
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

5.3 **Safely isolate** the gas system prior to decommissioning

Range:

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.

What do learners need to learn?

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.

5.4 Extract gas equipment and components from installation with appropriate handling techniques

What do learners need to learn?

Complete safe systems of work, risk assessments, method statements and select correct PPE when extracting equipment and components from installation.

5.5 Reinstate appropriate service post decommissioning

What do learners need to learn?

Reinstate all utilities to the system post-installation to facilitate commissioning and handover:

- Re-pressurise heating system following a replacement part
- Reinstate gas supply and test
- Reinstate electricity supply and test.

5.6 Maintain **safe working area**

Range:

Safe working area - well ventilated area, no ignition sources, good housekeeping, correct PPE.

What do learners need to learn?

Maintain a safe and clean working environment when installing gas systems and appliances.

5.7 Return clean installation to end user

What do learners need to learn?	**Skills**
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

5.8 Safe disposal of **waste products** when decommissioning gas system

Range:
Waste products - asbestos, dust, packaging, appliance, pipework.

What do learners need to learn?

Ensure all waste products are disposed of safely when decommissioning a gas system. Recycle as much waste as possible, remove any non-recyclable waste/hazardous waste and deposit at appropriate waste facility. Clean up any remaining mess.

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, SmartScreen worksheets (samples available) observation of measuring activities

  - Practical - Use of pre-set formative assessments carry out tasks and record on standardised form.
  - Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT

Ways of ensuring content is delivered in line with current, up to date industry practice

  - Delivery for this specialism will take place in a dedicated workshop with a range of gas appliances.
  - A realistic representation of UK gas systems and components should be installed in the workshop
  - Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
  - The provision must represent the type of equipment currently available in the UK gas industry
  - New and emerging gas technology should be included in the delivery e.g. smart controls

Suggested learning resources

Books

- The City and Guilds textbook: Plumbing book 2 for the level 3 Apprenticeship (9189). Level 3 Advanced Technical Diploma (8202) and Level 3 Diploma (6035) (City and Guilds)
- Gas Safe 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, 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 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 (42%)	T1- Planning the installation T2 – Install, commission, and decommission	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, commission, and decommission	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, commission, and decommission	Reports and information	Interpretation of drawings, specifications, manufacturer instructions

PO3 Commission gas systems (18%)	Task 2 - Install, commission and decommission	Inspecting and testing systems and components	Soundness testing, leaks, commissioning checks
	Task 2 - Install, commission and decommission	Health and Safety	Risk assessment, working safely, PPE
	Task 2 - Install, commission and decommission	Reports and information	Commissioning records
	Task 2 - Install, commission and decommission	Handover/ communication	Handover to customer
PO4 Maintain gas systems (23%)	T3 – Carry out Maintenance	Health and safety	Risk assessment, working safely, PPE
		Working with faults	Fault diagnosis, client requirements, Repair and replace components, use of tools
		Handover/ communication	Communication with customer to diagnose fault
		Reports and information	Maintenance activity report
PO5 Decommission gas systems (17%)	Task 2 - Install, commission and decommission	Health and Safety	Safe isolation process, safely isolate valves
		Systems and components	Extracting components, making good the building fabric, handling components and materials

355 Heating engineering

Level:	3
GLH – Combined with 356 Plumbing:	840
GLH – Combined with 359 Ventilation	765
Assessment method:	Practical assignment

What is this specialism about?

The purpose of this specialism is for learners to understand and undertake fundamental heating work. Learners will have the opportunity to plan, perform and evaluate their work 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 heating engineering work
- Heating engineering tools and equipment
- Pipework technology
- Heating systems
- Heating engineering science
- Regulations, legislation and industry guidance used in the heating industry.

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

- What does a heating engineer do?
- What tools and equipment do heating engineers use as part of their role?
- What are the steps required to become a qualified heating engineer?

Underpinning knowledge outcome

On completion of this specialism, learners will understand:

1. Heating knowledge criteria

Performance outcomes

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

2. Install heating systems
3. Commission heating systems
4. Maintain heating systems
5. Decommission heating systems

Completion of this specialism will give learners the opportunity to develop their maths, English and digital skills.

Specialism content

Outcome 1

Common knowledge Criteria

Health and safety

1.1 **Typical hazards** and associated risks with heating systems

Range:

Typical hazards - tripping hazards, slipping hazards, inadequate or lack of personal protective equipment, defective (unsafe) equipment, manual handling, working at heights, fire, electrocution, chemical injuries, inhalation of gases/chemicals.

What do learners need to learn?

The different controls that must be in place to minimise hazards occurring.

Safe use of electrical equipment and how to prevent electrocution.

Risks associated with the use of chemicals within the industry and how these can be categorised.

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 them, as follows:

- hoses
    - colours used
    - thread directions
    - flashback arrestors
    - dates
- control valves
- gauges
- blowpipes

Safe:

- bottle location and position

- equipment assembly sequence
- leak detection procedures
- 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

Tools, equipment and materials

1.2 Types of **tools, equipment** and **materials** used when working on heating systems

Range:

Tools - screwdriver, hammer, chisel, grip, wrench, spanner, spirit level, manual pipe threader, pipe cutter, hand saw, pliers, bending tool, blowtorch.

Power tools - power drill, circular saw, jig saw, reciprocating saws, portable pipe threading machine, hydraulic machine bender, hydraulic crimping kit, portable pipe freezing kit

Equipment access equipment, tape measure, digital measuring equipment.

Materials - copper pipework/fittings, LCS pipework/fittings, plastic pipework/fittings.

What do learners need to learn?

Common equipment and materials and their purpose.

New and emerging systems, tools and technology 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

1.3 Operation and handling requirements of tools

What do learners need to learn?

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.

Heating systems

1.4 Heating systems

Range:
Heating systems – wet central heating, warm air, storage heaters, district heating.

What do learners need to learn?

The different types of heating systems:
- pumped heating gravity hot water
- 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)
- combination boiler
- system boiler

Larger system control
- constant temperature
- variable temperature

Layout features:
- one pipe
- two pipe
- 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.

1.5 **Components** used in heating systems

Range:

Components – radiator valves – thermostatic and manual valves, automatic air vents, filling loop, pressure gauge, feed and expansion cisterns, circulating pumps, thermo-mechanical cylinder control valves, anti-gravity valves, drain valves, additives, low loss headers, buffers, pressure relief valves, expansion joints, corrosion filters, zone valves (two port, three port, mid position and diverter), low loss headers for multiple boiler installation, multiple heat producing appliances installation, programmer, timer, thermostats, programmable room stat, optimizer, frost stat, wiring centre, cylinder stat, expansion vessel, automatic by-pass, bespoke heat emitters, panel radiators, column radiators, low surface temperature radiators, fan convectors, plinth heaters, towel warmers, underfloor heating components, manifolds, pump control unit, insulation, pipework, manifold isolation ball valves, supports, controls.

What do learners need to learn?

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.

1.6 **Factors** that affect the choice and suitability of components in a heating system

Range:

Factors - appliances, purpose, size, location, cost, end users' needs, building regulation requirements, occupants, fuel availability, local availability.

What do learners need to learn? Factors that affect the choice and suitability of components included in a system, taking into consideration current regulations, industry guidance and best practice.	**Skills** EC5

1.7 **Appliances** supported by heating systems

Range:

Appliances – heat producing appliances, traditional boilers, condensing boilers, combination boilers, freestanding boilers, wall-mounted boilers, types of cylinder and ways of storing hot water (vented, unvented, thermal store).

What do learners need to learn?

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.

1.8 Types of waste and waste products found in different types of heating systems

What do learners need to learn?

Waste and waste products, their attributes (magnetite, corrosion), hazards to user and interaction with other parties including consumers.

Methods to reduce corrosion in systems.

Methods to remove existing corrosion using chemical flushing and power flushing methods.

1.9 **Safety devices** applicable to heating systems

Range

Safety devices - pressure/temperature relief valve, overheat thermostats, control thermostats.

What do learners need to learn?	**Skills**
Safety devices applicable to heating systems, their characteristics and operation. The typical operating pressures/temperatures of safety devices found in heating systems.	MC2

Heading engineering science

1.10 **Scientific principles** and concepts of heating engineering

Range:
Scientific principles - heat transfer, conduction, convection, radiation, heat loss.

What do learners need to learn?

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

1.11 Heating systems and the **combustion** process

Range:

Combustion - complete combustion, incomplete combustion, ventilation, flue draft, combustion triangle, stoichiometric, fuels, chemical, smouldering, diffusion, rapid, spontaneous.

What do learners need to learn?

The main constituents of complete and incomplete combustion for a range of fuels:

- Gas
- Oil
- Solid Fuel

The causes and signs of incomplete combustion.

The symptoms of carbon monoxide (CO) poisoning and the purpose of CO detectors.

1.12 **Flues/Chimneys** in relation to gas and the combustion process

Range:
Flues/Chimneys - open flued**,** room sealed.

What do learners need to learn?

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

1.13 Ventilation in relation to gas and the combustion process

What do learners need to learn?

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

Pipework technology

1.14 Types of **pipework**

Range:
Pipework - copper pipework/fittings, LCS pipework/fittings, plastic pipework/fittings, lead.

What do learners need to learn?

Characteristics of different types of pipework, including prefabricated and modularised components and distribution systems, different sizes, types of materials, their suitability for different situations and tools and equipment required.

The positioning and fixing of pipework within the building fabric

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
- low carbon steel (LCS)
    - light grade
    - medium grade
    - heavy grade
- plastic pipework
    - polyethylene (MDPE)
    - polybutylene
    - PVC-u
    - polypropylene
    - MUPVC
    - ABS
- lead

1.15 Jointing methods

What do learners need to learn?

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
- low carbon steel (LCS) pipe
    - threaded
    - compression
- plastic pressure pipe
    - push fit
    - compression
    - proprietary - copper and MDPE
- plastic jointing (sanitary for condense)
    - ring seal
    - compression
    - solvent

Methods of bending pipework:

- copper machine bending
    - 90° bends
    - sets and offset bends
    - passover bends
- copper spring bend

- LCS hydraulic machine bending
    - 90° bends
    - sets and offset bends
    - passover bends
- plastic pressure pipe
    - spring bend
    - cabling technique
    - cold forming bend

1.16 Types of **fitting**

Range:

Fitting - couplers/sockets, elbows and bends, equal tees, reducing tees, reducers, tap connectors, flexible connectors, manifolds, tank connectors, nipples, unions, flanges.

What do learners need to learn?

The different types and use of fitting and their suitability for different applications/material types.

1.17 Types of **support** and **fixings**

Range:

Support - saddle clip, Munson ring, plastic clip, LCS bracket, nail in clip.
Fixings - cavity fixings, nails, screws, wall plugs, anchor bolts.

What do learners need to learn?

Different types of pipework support and fixings, and their suitability for different systems, purposes and building fabrics.

Regulations, legislation and industry guidance

1.18 Implications of **legislation and additional guidance** to employers and those working with heating systems

Range:
Legislation and additional guidance – workplace information, company policies and procedures.

What do learners need to learn?

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

Specific knowledge criteria for performance outcomes

System installation (Outcome 2)

1.19 **Bending techniques**

Range:
Bending techniques - machine bending, hydraulic, scissor, hand (spring bend).

What do learners need to learn?

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

Low Carbon Steel (LCS) hydraulic machine bending:

- 90° bends
- sets and offset bends
- passover bends

The equipment used to carry out accurate bending of LCS and copper.

1.20 **Connection techniques**

Range:
Connection techniques - solder ring and end feed, compression, push-fit, press-fit, threaded, flanged.

What do learners need to learn?

Different types of connection techniques used during the installation and maintenance of heating systems and where and when to use them.

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

LCS pipe:
- threaded

Plastic pressure pipe
- push fit
- compression

System commissioning (Outcome 3)

1.21 **Inspection techniques**

Range:
Inspection techniques - visual inspection, pre-commissioning checks.

What do learners need to learn?	Skills
Inspection techniques and how they are applied during the pre-commissioning of heating systems in conjunction with manufacturer's instructions and current industry guidance.	EC5

1.22 **Factors** to inspect during pre-commissioning

Range:
Factors - appropriate checks to be made before commissioning, principles of commissioning.

What do learners need to learn?	**Skills**
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 and ductwork installed as specified and positioned as drawing • safety requirements adhered to • relevant people notified • relevant items cleaned wherever necessary 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	MC2 MC6

1.23 **Testing techniques** and their application

Range:
Testing techniques - soundness testing, safety component testing, performance testing.

What do learners need to learn?	**Skills**
The process for carrying out testing, including the type of test required for the system and the test pressures/durations in line with the relevant current British Standards. Soundness test to industry requirements on central 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	MC2 EC5

System maintenance (Outcome 4)

1.24 **Fault-finding techniques** and their application

Range:
Fault-finding techniques - end user, manufacturer's instructions, fault diagnosis flow charts, service history, industry experience.

What do learners need to learn?	Skills
Fault-finding techniques on system components through visual inspection of system, operational checks and performance testing to gather information to be used as part of analysis of situation.	EC5 MC2 DC1 DC5

1.25 **Causes** of **typical faults** in heating systems

Range:
Causes - poor installation, inadequate design, user error, environmental factors, appliance/ component malfunction.
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.

What do learners need to learn?	Skills
Repair and rectification procedures to deal with a range of typical faults found on a heating system: • 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 Typical causes of common heating faults and how they are identified during normal operation of a heating system.	MC2

1.26 Actions required when faults cannot be rectified

What do learners need to learn?	**Skills**
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	MC2 MC10 EC1 EC6

System decommissioning (Outcome 5)

1.27 **Procedures** involved in decommissioning

What do learners need to learn?

Step-by-step procedure for decommissioning heating systems

Procedure:
- 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 source of heat or supplies as required

Decommissioning:
- permanent
- temporary

1.28 Requirements for recording, labelling and reporting decommissioned systems

What do learners need to learn?	Skills
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 heating systems

Performance criteria

2.1 Install **pipework** relevant to the type of system

Range:
Pipework - copper pipework, LCS pipework, plastic pipework.

What do learners need to learn?	Skills
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.	MC1

2.2 Install **clips/brackets** to different types of **building fabric**

Range:
Clips/brackets - saddle clip, Munson ring, plastic clip, LCS bracket, nail in clip, school board clips.

Building fabric - timber, masonry, plasterboard.

What do learners need to learn?	Skills
Install and fix pipework clips and brackets at recommended spacing intervals to meet specification requirements and in line with current industry standards. Identify installation requirements for pipework: • prefabrication of pipework • installing pipework in-situ • use of sleeves • timber joist notching • first and second fix • pipework protection	MC1

2.3 Install **appliances**

Range:
Appliance – boilers

What do learners need to learn?	**Skills**
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.	MC1

2.4 Install **heat emitting devices**

Range:
Heat emitting devices - radiators, towel rails, skirting heaters, underfloor heating components.

What do learners need to learn?

Install a heat emitting device with consideration given to appropriate fixing for material, installation equipment and safety requirements during installation.

2.5 Install **components** to appliances

Range:
Components - diverter valves, safety controls, automatic air vents, circulating pumps.

What do learners need to learn?

Install components listed in the range into pre-installed appliances in line with manufacturer’s instructions.

2.6 Install **controls** into a range of systems

Range:
Controls - timing devices – clocks and programmers, room thermostats, hot water thermostats, smart controls, zone valves, automatic bypass valves.

What do learners need to learn?	**Skills**
Install components listed in the range into a range of systems in line with manufactures instructions.	DC6

2.7 Install **thermal insulation materials**

Range:
Thermal insulation materials - polyisocyanurate foam, PVC foam, polyethylene foam.

What do learners need to learn?

Select appropriate thermal installation materials for installation taking into consideration the material and suitability.

2.8 Install seals for heat emitting devices

What do learners need to learn?

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.

2.9 Check **heating products** are in accordance with design parameters

Range:
Heating products - radiator sizes, boiler size, zone valves, controls, pressure vessels, feed and expansion cisterns, circulating pumps.

What do learners need to learn?	**Skills**
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.	MC1 MC2 EC5

2.10 Install control systems for the **system**

Range:
System - fully pumped, 3 x 2 port valves (S plan Plus)

What do learners need to learn?	**Skills**
Install control systems for heating systems in line with manufacturer's instructions, current building regulations and British Standards.	EC5

2.11 Prepare a safe working environment to conduct heating system installation

What do learners need to learn?	**Skills**
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

2.12 Update line diagrams/installation plans

What do learners need to learn?	**Skills**
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

2.13 Use **hand and power tools** when penetrating a range of building fabrics

Range:
Hand and power tools - power drill, hand saw, hammer, wood chisel.

What do learners need to learn?

Use hand and power tools listed in the range to penetrate a range of building fabrics following safe systems of work (visual checks to ensure safe for use, PAT tested as appropriate, used in line with training and only where trained to do so).

2.14 Update digital building information management system software

What do learners need to learn?	Skills
Update basic information within a digital building information management system following heating installation. There is no requirement to create an installation plan/system plan within the system - updating of basic data as part of planning review is all that is required.	DC1 DC2 DC3 DC5 DC6

Outcome 3 - Commission heating systems

3.1 Assess risks associated with completing activities

What do learners need to learn?	**Skills**
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 employee's versus employers.	EC1 EC2 EC3 EC4

3.2 Set **heating controls**

Range:

Heating controls - programmer, time clock, thermostats, programmable room stat, optimiser, smart controls.

What do learners need to learn?	**Skills**
Set the heating controls and parameters in accordance with manufacturer's technical instructions and end user requirements.	EC5

3.3 Verify fitness for purpose of **tools/equipment**

Range:

Tools/equipment - thermometer, voltage indicating device.

What do learners need to learn? Verify fitness for purpose of tools/equipment using a known source.	**Skills** EC5

3.4 Complete heating system **handover documentation**

Range:

Handover documentation - benchmark logbook, handover pack- instructions, user guide, warranty information.

What do learners need to learn? Complete heating system handover documentation and pass to the end user. Explain details of this pack and provide full demonstration of all controls and equipment to end user.	**Skills** EC1 EC2 EC3 EC4 EC6

3.5 **Test** heating system installation

Range:

Test - temperature, flow rate, pressure.

What do learners need to learn? Perform appropriate soundness tests, in line with current industry requirements, on installed systems and components, with consideration given to materials used and testing method. Ensure tests conforms to original design requirements. Identify information sources required to complete testing and commissioning. Soundness test to include: • visual inspection • notify • initial fill • stabilisation • test to required pressure • check for leaks • check pressures after test period • complete documentation and notify as required	**Skills** MC1 MC2 EC5

3.6 Adjust heating system parameters to commission

What do learners need to learn?	Skills
Adjust heating system parameters to commission in accordance with manufacturer’s instructions.	EC5

3.7 Test heating system

What do learners need to learn?

Carry out the operational checks required during commissioning. Test system to include fully pumped, 3 x two port valves (S Plan Plus).

3.8 Record **commissioning results**

Range:

Commissioning results - temperature, flow rate, pressure.

What do learners need to learn?	Skills
Complete system commissioning records to industry standards with the required information outlining the actions that must be taken when commissioning reveals defects.	EC3 EC4

3.9 Visually inspect to check that correct equipment is utilised in the heating system

What do learners need to learn?

Visually inspect correct equipment is utilised in the heating system with reference to original specifications and diagrams.

3.10 Compare commissioning results against design parameters

What do learners need to learn?

Compare commissioning results against design parameters to determine correct installation in accordance with original design ensuring efficiency and compliance with manufacturer’s instructions.

Outcome 4 - Maintain heating systems

4.1 Identify any end user concerns around system operation

What do learners need to learn?	Skills
Use open questioning and listening to discuss maintenance requirements with end user /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, and how to overcome them, as well as to costs, sustainability and timescales.	EC1 EC2 EC3 EC4 EC5 EC6 MC2 MC6 DC3

4.2 Calculate maintenance downtime prior to deactivating

What do learners need to learn?	Skills
Calculate maintenance downtime prior to deactivating the system. Consideration should be given to information to be passed on to the end user, including the impact on the end user or industrial practice.	MC2 MC10

4.3 Conduct **fault finding**

Range:
Fault-finding - manufacturer's instructions, service history, end user.

What do learners need to learn?	Skills
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).	MC2 EC5

4.4 Engineer corrective measures to rectify fault

What do learners need to learn?	Skills
Carry out safely and in line with manufacturer’s requirements the repair and rectification procedures to deal with a range of 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	MC2 EC5

4.5 Assemble system **components**

Range:
Components - heat emitters, pumps, zone valves, expansion vessel.

What do learners need to learn?

Carry out the assembly of components as required, safely and in line with manufacturer’s requirements and industry standards.

4.6 Disassemble system components when conducting maintenance

What do learners need to learn?

Dissemble system with safe isolation and strip down of plumbing components following employer’s and manufacturer’s recognised process – systematically and with regard to minimising disruption and mess.

4.7 Repair faulty heating system **components** as identified

Range:

Components - radiator valves – thermostatic and manual valves, timing devices – clocks and programmers, room thermostats, hot water thermostats, zone valves (2 port, 4 port, mid position and diverter), circulating pumps, filling loop, pressure gauge, expansion vessel.

What do learners need to learn?

Carry out the maintenance and repair of components as required, safely and in line with manufacturer’s requirements and industry standards.

4.8 Classify waste for disposal and recycling

What do learners need to learn?

Classify waste for disposal and recycling in line with site management waste plans and approved disposal methods. Consideration should be given to safe/appropriate disposal of replaced components.

Outcome 5 - Decommission heating systems

5.1 Apply **control mechanisms** from a risk assessment prior to working

Range:
Control mechanisms - safe disposal of heating system fluids, safe isolation of fuel.

What do learners need to learn?	**Skills**
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	EC5

5.2 Communicate with user to establish **needs** when decommissioning heating

Range:
Needs - temporary heating requirements, duration, hot water requirements.

What do learners need to learn?	**Skills**
Discuss decommissioning requirements with end user, taking into consideration end user needs.	EC1 EC2 EC3 EC4 EC6 DC3 DC5

5.3 Safely electrically isolate the heating system prior to decommissioning

What do learners need to learn?

Safely isolate the heating system following the recognised safe isolation procedure and using the correct equipment.

The six-step safe isolation procedure:

- Identify
- Isolate
- Prove
- Test
- Re-prove
- Lock

5.4 Extract old **heating equipment** from installation

Range:
Heating equipment - boiler, radiators, components.

What do learners need to learn?

Remove pre-installed components from a pre-installed heating system using safe working practices.

5.5 Make good building fabric post system removal

What do learners need to learn?

Use construction materials to make good the building fabric following component or system removal - could include filling holes with plaster, removing waste build materials.

5.6 Reinstate appropriate **service** post-decommissioning

Range:
Service - electricity, water, fuel.

What do learners need to learn?

Reinstate appropriate services in the range post decommissioning, ensuring safety for the end user and compliance with industry standards.

5.7 **Safe disposal** of waste products when decommissioning heating systems

Range:

Safe disposal - licensed waste disposal, Waste Carriers license, recycling, specialist disposal – asbestos and other forms of hazardous waste.

What do learners need to learn?

Safely dispose of waste products when decommissioning heating systems. Use appropriate method of disposal for the type of waste product.

Decommissioning of heating systems could include sealed systems and open vented systems.

Core content

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

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 – Heaters, radiators
- 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, SmartScreen worksheets (samples available) observation of measuring activities

- Practical –Use of pre-set formative assessments carry out tasks and record on standardised form
- Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT

Ways of ensuring content is delivered in line with current, up to date industry practice

- Centres will need to ensure a realistic representation of heating systems and components
- Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
- The provision must represent the type of equipment currently available in the UK heating industry
- Staff delivering the qualification should be technically competent and have up to date industry CPD
- Current and emerging heating technology should be included in delivery e.g. smart controls

Suggested learning resources

Books

- The City & Guilds Textbook: Plumbing Book 2 for the Level 3 Apprenticeship (9189), Level 3 Advanced Technical Diploma (8202) and Level 3 Diploma (6035) (City & Guilds)
- Collins Complete Plumbing and Central Heating (Collins)
- CORGIdirect Commercial Heating Manual - Non-Domestic - ND3 (CORGIdirect)
- CORGIdirect Central Heating - Wet and Dry Manual - GID7 (New 5th Edition)

(CORGIdirect)

- The Domestic Heating Design Guide (DHDG) - CIBSE

Websites

- 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/**
- Honeywell - **https://heatingcontrols.honeywellhome.com/**
- 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://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/697525/DBSCG_secure.pdf**
- HDVH domestic heating design guide CIBSI https://www.cibse.org/knowledge/knowledge-items/detail?id=a0q20000008I7odAAC

Scheme of Assessment – Heating engineering

The Heating engineering occupational specialism is assessed by one practical assignment. The duration of the assessment is 20 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 heating 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 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 heating systems (36%)	T1- Planning the installation T2 – Install, commission, and decommission	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, commission, and decommission	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, commission, and decommission	Reports and information	Interpretation of drawings, specifications, manufacturer instructions
PO3 Commission heating systems (24%)	Task 2 - Install, commission and decommission	Inspecting and testing systems and components	Soundness testing, leaks, commissioning checks

	Task 2 - Install, commission and decommission	Health and Safety	Risk assessment, working safely, PPE
	Task 2 - Install, commission and decommission	Reports and information	Commissioning records
	Task 2 - Install, commission and decommission	Handover/ communication	Handover to customer
PO4 Maintain heating systems (26%)	T3 – Carry out Maintenance	Health and safety	Risk assessment, working safely, PPE
		Working with faults	Fault diagnosis, client requirements, Repair and replace components, use of tools
		Handover/ communication	Communication with customer to diagnose fault
		Reports and information	Maintenance activity report
PO5 Decommission heating systems (14%)	Task 2 - Install, commission and decommission	Health and Safety	Safe isolation process, safely isolate valves
		Systems and components	Extracting components, making good the building fabric, handling components and materials

356 Plumbing engineering

Level:	3
GLH – Combined with 355 Heating:	840
Assessment method:	Practical assignment

What is this specialism about?

The purpose of this specialism is for learners to learn about and undertake fundamental plumbing work. Learners will have the opportunity to plan, perform and evaluate their work while using a range of materials, methods and techniques.

Learners will develop their knowledge, understanding and skills of:

- Fundamental health and safety practices associated with carrying out plumbing work.
- Plumbing tools and equipment
- Pipework materials, installation methods and jointing processes.
- Plumbing systems and their purpose
- Plumbing science
- Principles of measurement and marking out components and pipework

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

- What kind of tasks does a plumber perform?
- What systems do plumber's work on?
- What tools and equipment do plumber's use as part of their role?

Underpinning knowledge outcome

On completion of this specialism, learners will understand:
1. Plumbing knowledge criteria

Performance outcomes

On completion of this specialism, learners will be able to:
2. Install plumbing systems
3. Commission plumbing systems
4. Maintain plumbing systems
5. Decommission plumbing systems

Completion of this specialism will give learners the opportunity to develop their maths, English and digital skills.

Specialism content

Outcome 1

Common knowledge criteria

Health and safety

1.1 Key requirements of **Codes of Practice (CoP)**

Range:

Codes of practice (CoP) – L5 Control of substances hazardous to health, L8 Legionnaires' disease – the control of *Legionella* bacteria in water systems, L21 Management of health and safety at work, L22 Provision and Use of Work Equipment Regulations 1998, L23 Manual handling – Manual Handling Operations Regulations 1992, L25 Personal protective equipment at work, L74 The Health and Safety (First Aid) Regulations 1981, guidance on regulations.

What do learners need to learn?	Skills
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

1.2 **Typical hazards** and risks associated with plumbing systems

Range:

Typical hazards - tripping hazards, slipping hazards, inadequate or lack of personal protective equipment, defective (unsafe) equipment, manual handling, working at heights, electrocution, safe use of heat-producing equipment.

What do learners need to learn?

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

Tools, equipment and materials

1.3 **Tools**, equipment and **materials** used for installation

Range:
Tools – screwdriver, hammer, chisel, grip, wrench, spanner, spirit level, manual pipe threader, pipe cutter, hand saw, plier, bending tool, soldering equipment, pressfit, tape measure, measuring equipment.

Materials - copper pipework/fittings, LCS pipework/fittings, plastic pipework/fittings, sanitary appliances.

What do learners need to learn?

Common equipment and materials and their purpose. New and emerging systems, tools and technology used to ensure currency of practice. Additional tools and equipment that can be used for adapted ways of working. How to store tools and equipment appropriately.

The sources of information for carrying out preparatory work, to include:

- statutory regulations
- industry standards
- manufacturers' 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 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

1.4 Operation and handling requirements for tools and equipment

What do learners need to learn?

The use of electricity for powered tools and the specific safety considerations relating to their use and hazards. Maintenance schedules and processes for escalating or reporting broken, unsafe or faulty equipment. PAT test requirements, PPE requirements.

Plumbing systems

1.5 **Sources** and distribution of water

Range:
Surface sources - lakes, reservoirs, rivers, streams**.**

Underground sources - deep and shallow wells, artesian wells, bore-holes, springs.

What do learners need to learn?

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

1.6 **Plumbing systems**

Range:

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.

What do learners need to learn?

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

1.7 **Components** used in plumbing systems

Range:

Components - WC flushing cistern, sink tap, terminal fittings, bath, drain valves, blending valves, check valves, air admittance valves, float operated valves, service valves, supply stop valves, WC, basin, appliance trap, flushing syphons water treatment, water softeners/conditioners/filters, booster pumps, accumulators, showers, dishwashers, washing machines, cylinders.

What do learners need to learn?

Components used in plumbing systems, their characteristics and function within the system and how they work together to support the operation of the system.

1.8 **Factors** that affect the choice and suitability of components in a system

Range:

Factors - appliances, purpose, size, location, temperature, flow rate, pressure, environmental, customer needs.

What do learners need to learn? Factors that affect the choice and suitability of components included in a system.	**Skills** EC5

1.9 Types of **control systems** required for plumbing systems

Range:

Control systems - digital water controls**,** solenoid valves**,** infrared controls**,** water treatment.

What do learners need to learn?

Types of control systems required for plumbing systems including digital controls, their characteristics, operation and suitability for different situations.

1.10 **Appliances** supported by plumbing systems

Range:
Appliances - WC, basin, bath, shower, urinal.

What do learners need to learn?

Common appliances connected to plumbing systems: their limitations, operating parameters, waste outputs and fluid categories.

1.11 Types of waste and waste products and the associated **systems** and **attributes**

Range:
Systems - septic tanks, wastewater lifters**,** macerators.
Attributes - smells, bacteria.

What do learners need to learn?

Main types of waste and waste products including types of systems. The hazards to user and interaction with other parties including the undertaker and treatment.

1.12 The effects of damage interference from **external sources** on system operation

Range:
External sources - electrolytic action, atmospheric corrosion, chemical damage, water damage, heat damage, mechanical damage, UV damage, freezing, cold, vibration.

What do learners need to learn?

Potential effects of damage interference from external sources on system operation.

Plumbing science

1.13 **Scientific principles** and concepts to plumbing engineering

Range:

Scientific principles - relative densities, properties of solid materials, corrosion prevention, application of liquids and gases, properties of liquids and gases.

What do learners need to learn?	**Skills**
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 • LPG • natural gas • carbon dioxide • refrigerant gases Properties of liquids: • water o boiling/freezing point o relationship Celsius and Kelvin o change of state and molecular changes o volume and pressure increases o density at differing temperatures o to steam/super heated steam o capillarity o acidity/alkalinity (pH value) o water hardness o soft o temporary hard	MC4

    - 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.
Water quality (including pH) and treatments.

1.14 Relationship between flow and pressure

What do learners need to learn?

Relationship between flow and pressure for both liquids and gases to include Boyle's law and Charles's L law.

1.15 Relationship between mass/volume and specific heat capacity

What do learners need to learn?	Skills
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

1.16 Types of **insulation materials**

Range:
Insulation materials - polyisocyanurate foam, PVC foam, polyethylene foam.

What do learners need to learn?

Types of insulation materials, their properties including relevant standards and current building regulations and their suitability for different systems.

1.17 Electrolyte qualities of materials and the periodic table

What do learners need to learn?

Electrolyte qualities of materials – the type, installation and size of pipework and fittings and their effect on flow rates.

Pipework technology

1.18 Characteristics of types of **pipework**

Range:
Pipework - prefabricated components, modularised components, Onsite installation.

What do learners need to learn?

Characteristics of different types of pipework including prefabricated and modularised components and distribution systems, different sizes, types of materials, their suitability for different situations, and tools and equipment (including fixings) required.

1.19 Types of **support**, fittings and **fixings**

Range:
Support - saddle clip, munson ring, plastic clip, LCS bracket, waste pipe clip, soil pipe clip, nail in clip, gutter and rainwater clips.

Fixings - cavity fixings, nails, screws, wall plug, appliance fixing kit, anchor bolts.

What do learners need to learn?

Different types of support, fixings and fittings, and their purpose and suitability for different systems and building fabrics.

Information and data

1.20 Plumbing drawing symbols and markings

What do learners need to learn?	Skills
Common drawing symbols and markings.	EC3

1.21 Types of **documentation**

Range:

Documentation - commissioning record, maintenance record, delivery note, job specification, working drawings, work programme, plans, quotations and estimates, invoice, risk assessment, method statement.

What do learners need to learn?	Skills
Different types of documentation, the specific content of different documents and what they are used for.	EC3 EC5 MC1 MC2

Measurement

1.22 **Metric and imperial dimensions**

Range:

Metric and imperial dimensions - metre (length) m, kilogram (mass) kg, feet**,** inches**,** centre metre**,** millimetre, bar (metric unit of pressure)**,** PSI (pounds per square inch, or pound force per square inch).

What do learners need to learn?	Skills
The metric and imperial dimensions of height, weight, length and pressure.	MC1 MC3 MC4

Specific knowledge criteria for performance outcomes

System installation (Outcome 2)

1. Plumbing knowledge criteria

1.23 **Bending techniques**

Range:
Bending techniques - machine**,** scissor, hand (spring bend), pre-formed.

What do learners need to learn?

Different types of bending techniques and when they would be used. The equipment used to carry out accurate bending of low carbon steel (LCS) and copper.

Methods of bending pipework

Copper machine bending:

- 90° bends
- sets and offset bends
- passover bends
- copper spring bend

LCS hydraulic machine bending:

- 90° bends
- sets and offset bends
- passover bends

Plastic pressure pipe

- spring bend
- cabling technique
- cold forming bend

1.24 **Connection techniques**

Range:

Connection techniques - solder ring and end feed, compression, push-fit, press-fit, threaded, solvent.

What do learners need to learn?

Different types of connection techniques 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

Low carbon steel (LCS) pipe:

- threaded

Plastic pressure pipe:

- push fit
- compression
- proprietary
- copper and MDPE
-

Plastic jointing (sanitary):

- ring seal
- compression
- solvent

1.25 Potential **impact** of installation activities

Range:
Impact – no water, temporary loss of water, delayed arrival of resource or materials.

What do learners need to learn?

Potential impacts of installation activities on customer essential services and the ways these can be minimised:

- Isolation of services
- Preparation of temporary services – providing water during temporary loss
- Completing work out of hours or when unoccupied – cost related disability (no sanitation services)

System commissioning (Outcome 3)

1.26 **Inspection techniques**

Range:
Inspection techniques - visual inspection.

What do learners need to learn?	Skills
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.	EC5

1.27 **Factors** to inspect during commissioning

Range:
Factors – temperature**,** flow rate**,** pressure.

What do learners need to learn?	Skills
The factors to inspect during commissioning and how expected standards are defined in relation to manufacturer's guidance and building regulations. 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 and ductwork installed as specified and positioned as drawing • safety requirements adhered to • relevant people notified • relevant items cleaned wherever necessary	MC2 MC6

1.28 **Testing techniques**

Range:

Testing techniques - air testing, hydraulic pressure testing, safety component operation**,** soundness testing**,** performance testing.

What do learners need to learn?	**Skills**
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 system pipework and components: • initial fill • stabilisation • test to required pressure • check for leaks • heck pressures after test period Operational checks: • temperature • flow rate • pressure • controls	MC2 EC5

1.29 **Documentation** required for commissioning and verification of commissioning

Range:

Documentation - commissioning record**,** service sheet**,** warranty information**,** manufacturer's guarantees, self-certification.

What do learners need to learn? The different documentation required for commissioning and verification of commissioning, its content, and when and how it is used within the commissioning process.	**Skills** EC5

1.30 **Technical information** required for use by different **stakeholders**

Range:

Technical information - handover pack**,** instructions**,** user guides**,** service requirements.

Stakeholders - client/customer, installer, tenant, end user.

What do learners need to learn? The types of technical information and different stakeholders. Completion of technical information, and who to pass it on to once complete.	**Skills** EC1 EC3 EC4 DC2 DC3

System maintenance (Outcome 4)

1.31 **Fault-finding techniques**

Range:

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.

What do learners need to learn?	Skills
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 and how to carry out diagnostic checks with reference to fault diagnosis flow charts.	EC5 MC2 DC1 DC5

1.32 **Causes** of typical faults in plumbing

Range:

Causes - poor installation, inadequate design, user error, environmental factors.

What do learners need to learn?	Skills
Common faults in plumbing systems, and how they are caused during normal operation of a plumbing system. Repair and rectification procedures to deal with a range of typical faults found on a heating system: • 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	MC2

1.33 **Documentation** required for maintenance and verification of maintenance activities

Range:

Documentation - manufacturer's instructions**,** maintenance record**,** maintenance programme, maintenance checklist, service history, job sheets.

What do learners need to learn?	Skills
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.	EC5

1.34 **Actions** required when faults cannot be rectified

Range:

Actions - notify end user, make appliance safe, apply warning notices/signs, discuss next steps.

What do learners need to learn?	Skills
The actions required when faults cannot be rectified, and the potential implications to customer and business, including time, costs, loss or temporary loss of industry operations and alternative provisions.	MC2 MC10 EC1 EC6

System decommissioning (Outcome 5)

1.35 Procedures involved in decommissioning **systems**

Range:

Systems - above ground drainage, below ground drainage, rainwater harvesting, grey water re-use, rainwater systems, hot water, cold water.

What do learners need to learn?

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

1.36 **Waste management procedures**

Range:

Waste management procedures - licensed waste disposal, Waste Carriers Licence, recycling, specialist disposal, transport of licenced waste.

What do learners need to learn?

Waste management procedures and own role and responsibilities. Relevant procedure for type of waste. Materials that can be recycled (metals, plastics, wood/cardboard).

1.37 Safe removal of different **types of waste** from the working area

Range:

Types of waste - asbestos, materials**,** contaminated water, recyclable, non-recyclable.

What do learners need to learn?

Methods used to safely remove different types of waste from the working area for both licensed and unlicensed disposal.

1.38 **Documentation** required for decommissioning and verification of **decommissioning activities**

Range:

Documentation - job sheet**,** decommissioning record sheet.

Decommissioning activities - domestic installations**,** industrial and commercial installations**.**

What do learners need to learn?	**Skills**
Documentation required for decommissioning and verification of decommissioning activities, their content and purpose.	EC1 EC3 EC4 EC5

1.39 Requirements for recording, labelling and reporting decommissioned systems

What do learners need to learn?	**Skills**
Requirements for recording, labelling and reporting decommissioned systems to prevent the use of decommissioned appliances, by informing the responsible person, warning notices, labels, notifying other trades.	EC1 EC6

Outcome 2 - Install plumbing systems

Performance criteria

2.1 Interpret risk assessments and related documentation

What do learners need to learn?

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

Skills
EC4
EC5

2.2 Select **tools**, equipment and **materials**

Range:
Tools-screwdriver, hammer, chisel, grip, wrench, spanner, spirit level, manual pipe threader, pipe cutter, hand saw, pliers, bending tool, blowtorch.

Materials - copper pipework/fittings, LCS pipework/fittings, plastic pipework/fittings.

What do learners need to learn?

Select the correct hand and power tools required to complete work activities on plumbing systems, taking into consideration the safe use of the equipment and suitability of tools and equipment matched to specific tasks.

2.3 Measure site requirements and materials

What do learners need to learn?	Skills
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

2.4 Mark out **requirements**

Range:
Requirements - notching timber floor joists, drilling holes – timber floor joists, pipework clipping distances.

What do learners need to learn?	Skills
Prepare the building fabric for the installation of pipework and plumbing components in line with building regulations and industry standards.	MC1 EC5

2.5 Use hand and power **tools**

Range:
Tools - power drill, hand saw, hydraulic machine bender, hydraulic crimping kit.

What do learners need to learn?
Use hand and power tools to secure and install plumbing pipework and appliances following safe systems of work (visual checks to ensure safe for use, PAT tested as appropriate, used in line with training and only where trained to do so).

2.6 Prefabricate pipes by bending to **shape**

Range:
Shape - 90° angle**,** offset angle, Passover.

What do learners need to learn?

Bend pipes to meet the needs of the pipework specification, use appropriate material (copper, low carbon steel (LCS), plastic) and specific site considerations
Use appropriate bending equipment/bending machine, safely and in line with manufacturer’s instructions.

2.7 Cut **pipes**

Range
Pipes - copper pipework, LCS pipework, plastic pipework.

What do learners need to learn?	**Skills** MC1
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.	

2.8 Connect materials using **jointing methods**

Range:

Jointing methods - copper pipe – solder ring and end feed, compression (type A and B), push-fit, press-fit; low-carbon steel (LCS) pipe – threaded, plastic pipe (hot, cold and heating), push-fit, compression, proprietary; copper and MDPE – plastic jointing (sanitary), ring seal, compression.

What do learners need to learn?	**Skills** MC1
Connect pipework together using the appropriate jointing method for materials, equipment and safety requirements.	

2.9 Fix **pipework** to **structures**

Range:

Pipework - copper pipework**,** LCS pipework**,** plastic pipework.

Structures – timber, masonry.

What do learners need to learn?	**Skills**
Fix pipework clips and brackets at recommended spacing intervals to meet specification requirements and in line with current industry standards.	MC1

2.10 Position and secure **components** in plumbing **system**

Range:

Components - WC flushing cistern, sink tap, wash hand basin tap, drain valves, float operated valves, service valves, supply stop valves, WC, basin, bath, appliance trap.

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.

What do learners need to learn?	**Skills**
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.	MC1

2.11 Interpret **information** provided

Range:

Information - plans/drawings, job specifications, work programmes, installation instructions, local site considerations.

What do learners need to learn?	**Skills**
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.	EC2 EC5 MC7

2.12 Update digital building information management system software

What do learners need to learn?	Skills
Update basic information within a digital building information management system following plumbing installation. There is no requirement to create an installation plan/system plan within the system - updating of basic data as part of a planning review is all that is required.	DC1 DC2 DC3 DC5 DC6

Outcome 3 - Commission plumbing systems

3.1 Assess risks associated with completing activities

What do learners need to learn?	Skills
Produce a risk assessment for commissioning activities in accordance with the five stages of assessment: • identification of hazards • identification of who is at risk and how • assessment of risk and action • recording of findings • review of risk assessment Record risk assessment findings in line with regulations, as well as the responsibilities of employees versus employers.	EC1 EC2 EC3 EC4

3.2 Interpret information and data

What do learners need to learn?	Skills
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

3.3 Inspect the installation of components

What do learners need to learn?	Skills
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

3.4 Test **systems**

Range:
Systems - cold water, hot water, sanitation, rainwater.

What do learners need to learn?	**Skills**
Perform appropriate soundness tests, in line with current industry requirements, on installed systems and components, with consideration given to materials used and testing methods. 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: • cold • disinfection System additives: • neutralisers • cleanser • water softener (salt)	MC1

3.5 Ensure accuracy and compliance with **intended outcomes**

Range:
Intended outcomes – temperature, flow rate, pressure, electrical controls, mechanical controls, functional testing.

What do learners need to learn?

Carry out operational checks required during commissioning
Commissioning procedure:

- visual inspection
- fill and vent
- soundness test
- flush
- operational checks
- commissioning documentation
- handover procedure

3.6 Record data from commissioning **checks**

Range:
Checks – temperature**,** flow rate, pressure, operation of controls, functional checks.

What do learners need to learn?	**Skills**
Measure and record system information using recognised methods in line with the requirements of current building regulations.	EC3 EC4

3.7 Complete required **documentation**

Range:
Documentation - commissioning record, service sheet**,** benchmark/appliance certificates.

What do learners need to learn?	**Skills**
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.	EC3 EC4 MC7

3.8 Present technical information orally for different stakeholders

What do learners need to learn?	**Skills**
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, and 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 systems

4.1 Identify information **requirements** from a brief

Range:
Requirements - end user, manufacturer’s instructions, fault diagnosis flow chart, service history.

What do learners need to know?	Skills
Check all necessary job information is available before commencing the maintenance work with reference to manufacturer’s requirements and guidance.	EC5 MC2 MC6

4.2 Explore end user or client requirements

What do learners need to learn?	Skills
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

4.3 Estimate and calculate time and resources

What do learners need to learn?	Skills
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

4.4 Analyse situations to identify potential causes for delays and errors

What do learners need to learn?	**Skills**
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

4.5 Inspect the suitability of materials, **tools and equipment**

Range:

Tools and equipment - screwdriver, hammer, chisel, grip, wrench, adjustable spanner/ adjustable spanner, spirit level, pipe cutter, circlip pliers, pliers, plunger, tap reseating tool, drain auger, drain rods, copper pipework/fittings, LCS pipework/fittings, plastic pipework/fittings, pressure gauge, flow cup, thermometer.

What do learners need to learn?
Check tools, materials and equipment for suitability via visual inspection or relevant checks, including reporting and removal procedures for faulty or inappropriate items.

4.6 Analyse situations to identify potential faults

What do learners need to learn?	**Skills**
Complete inspection for potential faults on system components through visual inspection of system, operational checks and performance testing to gather information to be used as part of analysis of situation. Refer to manufacturer's instructions or specifications (fault-finding flow chart).	MC2 MC7 EC5

4.7 Repair **component faults** in systems

Range:

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.

What do learners need to learn?

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).

4.8 Disassemble **parts** of a system

Range:

Parts - WC flushing cistern, sink tap, wash hand basin tap, shower mixer valve, sanitary appliance trap, hot/cold sanitary pipework.

What do learners need to learn?

System disassembly with safe isolation and strip down of plumbing components following employer's and manufacturer's recognised process – systematically and with regard to minimising disruption and mess.

4.9 Replace **components** within a system

Range:

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.

What do learners need to learn?

Replace components within a system as necessary to meet industry and task-specific requirements. Use safe and appropriate methods to dispose of replaced components.

Outcome 5 - Decommission plumbing systems

5.1 Safely isolate valves/services to **types of systems**

Range:

Types of system: cold water, hot water, sanitation.

What do learners need to learn?

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

Skills
EC1
EC2
EC3
EC4
EC5
EC6

5.2 Handle **materials** to protect their integrity and safety

Range:
Materials - components**,** pipework materials.

What do learners need to learn?

Handle materials to protect their integrity and safety during decommissioning.
Adopt safe storage of components and materials following health and safety procedures.

5.3 Extract **components** from systems

Range:
Components - WC flushing cistern, sink tap, wash hand basin tap, bath, drain valves, float operated valves, service valves, supply stop valves, WC, basin, appliance trap, cylinders.

What do learners need to learn?

Remove pre-installed components from plumbing systems following recognised industry practices.

5.4 Reconfigure systems

What do learners need to learn?

Reconfigure plumbing systems during the decommissioning process, ensuring the system is left in full working order.

5.5 Make good the building fabric.

What do learners need to learn?

Use construction materials to make good the building fabric following component or system removal - filling holes with plaster, removing waste build materials.

5.6 Categorise **waste**

Range:
Waste – licenced, recyclable, specialist, general site.

What do learners need to learn? 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.	**Skills** 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 and sanitation and drainage
- 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, SmartScreen worksheets (samples available) observation of measuring activities

- Practical - Use of pre-set formative assessments carry out tasks and record on standardised form.
- Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT

Ways of ensuring content is delivered in line with current, up to date industry practice

- Centres will need to ensure a realistic representation of plumbing systems and components are available
- Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
- The provision must represent the type of equipment currently available in the UK ventilation industry
- Current and emerging plumbing technology should be included in delivery where possible

Suggested learning resources

Books

- The City & Guilds Textbook: Plumbing Book 2 for the Level 3 Apprenticeship (9189), Level 3 Advanced Technical Diploma (8202) and Level 3 Diploma (6035) (City & Guilds)
- Collins Complete Plumbing and Central Heating (Collins)
- Plumbing Encyclopaedia 4th edition RD (Treloar)
- Water Regulations Guide by **Laurrie Young** (Author), **Graham Mays** (Author)

Websites

- WaterSafe https://www.watersafe.org.uk
- https://www.wras.co.uk/
- National Careers Service https://nationalcareers.service.gov.uk/job-profiles/plumber
- CIPHE- **https://www.ciphe.org.uk/**
- Planning portal **https://www.planningportal.co.uk/**
- British Standards Institution **https://shop.bsigroup.com/**
- **https://www.pegleryorkshire.co.uk/**
- Association of Plumbing and Heating Contractors https://www.aphc.co.uk/
- **https://www.wras.co.uk/resources_for_applicants/**

Scheme of Assessment – Plumbing engineering

The Plumbing engineering occupational specialism is assessed by one practical assignment. The duration of the assessment is 20 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 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 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 systems (40%)	T1- Planning the installation T2 – Install, commission, and decommission	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, commission, and decommission	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, commission, and decommission	Reports and information	Interpretation of drawings, specifications, manufacturer instructions

PO3 Commission plumbing systems (20%)	Task 2 - Install, commission and decommission	Inspecting and testing systems and components	Soundness testing, leaks, commissioning checks
	Task 2 - Install, commission and decommission	Health and Safety	Risk assessment, working safely, PPE
	Task 2 - Install, commission and decommission	Reports and information	Commissioning records
	Task 2 - Install, commission and decommission	Handover/ communication	Handover to customer
PO4 Maintain plumbing systems (23%)	T3 – Carry out Maintenance	Health and safety	Risk assessment, working safely, PPE
		Working with faults	Fault diagnosis, client requirements, Repair and replace components, use of tools
		Handover/ communication	Communication with customer to diagnose fault
		Reports and information	Maintenance activity report
PO5 Decommission plumbing systems (17%)	Task 2 - Install, commission and decommission	Health and Safety	Safe isolation process, safely isolate valves
		Systems and components	Extracting components, making good the building fabric, handling components and materials

357 Protection systems engineering

Level:	3
GLH:	570
Assessment method:	Practical assignment

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

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

- What data and details are needed when planning protection system installations?
- What types of checks and adjustments may be required to protection systems during and after installation?
- Where is system data relating to protection system maintenance recorded?

Underpinning knowledge outcome

On completion of this specialism, learners will understand:

1. Protection systems engineering knowledge criteria

Performance outcomes

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

2. Install protection systems
3. Commission protection systems
4. Maintain protection systems
5. Decommission protection systems

Completion of this specialism will give learners the opportunity to develop their maths, English and digital skills.

Specialism content

Outcome 1

Common knowledge criteria

Health and safety

1.1 **Safe working practices** specific to work on protection systems

Range:

Safe working practices - carrying out safe isolation before working on 230 V AC connections to systems and equipment, selection of appropriate tools for isolation in accordance with GS 38, discharge / disconnection of stand-by supplies, requirements for working with and disposing of chemical batteries and detection devices, requirements for working with fibre optic cables.

What do learners need to learn?	Skills
Safe working practices with reference to full, current industry recognised electrical safe isolation and lock-off procedures. Hazards and PPE associated with working with chemical and radioactive equipment, and fibre-optic cables.	EC5

Science

1.2 Electrical/electronic science principles

Range:

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.

What do learners need to learn?	Skills
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.	MC5 MC6

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, LEDs. 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 and resolve series and parallel capacitor circuits. 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 and mutual induced EMF. Construction and basic operation of transformers. Typical applications. Calculations to determine the effects of transformer turns ratio on voltage and current. Basic construction, operation and function of the listed semiconductor devices. Recognise common devices, and the means of identifying polarity. Typical applications. Semiconductor devices: silicon diode, light emitting diode (LED), NPN bipolar transistor.	

Tools, equipment and materials

1.3 **Tools** and **equipment** used when working with protection systems

Range:

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

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

Equipment - multimeter, RF signal strength meter, network cable tester, insulation resistance tester, smoke hoods, smoke cannisters, testing/commissioning equipment, programming devices, programming software.

What do learners need to learn?

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 may 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.

1.4 Operation and handling requirements of tools and commissioning equipment

What do learners need to learn?

User checks, calibration checks, operation/function of equipment.

Protection systems

1.5 Types of **protection systems, signalling and notification**

Range:

Protection systems - fire detection systems (conventional, addressable), access control systems, video surveillance (CCTV), intruder and hold up alarm systems (I&HAS), and addressable emergency lighting systems.

Signalling and notification - Specifications and devices used for signalling and notification in protection systems.

What do learners need to learn?

Reference to guidance on different types of protection systems used in different building environments. Reference must be made to relevant British Standards and manufacturer's literature. This will range from conventional basic systems to intelligent digital addressable systems at different voltage levels.

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 app’s)

1.6 Protection system **components**

Range:

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.

What do learners need to learn?	**Skills**
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 UPS for standby applications for equipment such as NVR’s, administration PC’s and servers.	DC1 DC5 DC6

1.7 Protection system **circuits**

Range:

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.

What do learners need to learn?	**Skills**
Circuit properties including suitability, applications, advantages and limitations for given protection system. Data bus topologies and connection. Effects of series and parallel resistances and configurations. Effects of voltage drop.	MC7

Specific knowledge criteria for performance outcomes

System installation (Outcome 2)

1.8 Methods of selecting and installing **cable installation and wiring support systems**

Range:

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 PVC), cable trunking (steel and PVC), ladder racking, cable basket.

What do learners need to learn?	**Skills**
How to install cables and containment in line with current legislation and industry practices. Need for segregation of particular cable systems. When installing cables consideration should be given to building regulations, manufacturer's instructions and British Standards. Selection of cable suitable for current capacity, voltage drop limitations, signal transmission type, and environment. Selection of wiring support system suitable for environment, type and quantity of cables, and availability of fixing methods.	EC4

1.9 Termination of **cables**

Range:

Cables - single and multi-core thermoplastic cable, FP200 – fire resistant cable, CAT5e/6e data cable, UTP and STP data cables, coaxial, shielded data cable.

What do learners need to learn?

Termination and securing of cable glands detailed in the range in line with specification requirements and current industry standards/working methods. When securing terminations consideration should be taken of Building Regulations, manufacturer's instructions and British Standards.

1.10 Methods of **terminating and connecting** conductors

Range:

Terminating and connecting - screwed, crimped, compression, insulation displacement, clamp.

What do learners need to learn?

Termination and connection of conductors as detailed in the range in line with specification requirements and current industry standards/working methods. When securing terminations/connections consideration should be given to building regulations, manufacturer's instructions and British Standards.

Consideration of advantages and limitations of termination and connection methods and consequences of poor connections.

Shape and type of material being connected, junction of materials and volume/number of conductors.

1.11 Methods of supporting protective system components

What do learners need to learn?

Selection of appropriate fixing methods, considering load bearing, environment, building structure/materials and aesthetics.

System commissioning (Outcome 3)

1.12 Inspections of protection systems

What do learners need to learn?

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 O&M manuals.

1.13 Testing of protection systems

What do learners need to learn?	**Skills**
Tests to be carried out on electronic protection systems in line with relevant current standards and codes of practice, and manufacturers 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

1.14 Verification of protection systems

What do learners need to learn?

Verifying compliance with system design and manufacturers 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.

System maintenance (Outcome 4)

1.15 Types of protection **system maintenance**

Range:

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

What do learners need to learn?

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

Advantages and limitations of PPM and reactive maintenance. Requirements for completing documentation and updating O&M manuals.

The tests that must be carried out during a maintenance activity for each of the listed protection systems.

1.16 **Fault-finding** and **rectification techniques**

Range:

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 - repair, replace, adjust.

What do learners need to learn?	**Skills**
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

1.17 Maintenance requirements for different **building types** and locations

Range:

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

What do learners need to learn?	**Skills**

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

1.18 Maintenance of older systems and installations

What do learners need to learn?

Identification of older systems that may not be compliant with current regulations and reporting on condition and suitability for continued use.

System decommissioning (Outcome 5)

1.19 Making systems safe to decommission

What do learners need to learn?

Isolation of systems from the supply source or 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.

1.20 Methods of identifying potential issues before decommissioning systems

What do learners need to learn? Methods including reviewing O&M manuals, and consultation of component data sheets and drawings. Benefits of devising a timely plan when decommissioning systems.	**Skills** MC2 EC5

Outcome 2 - Install protection systems

Performance criteria

2.1 Assess risk associated with tasks

What do learners need to learn?	**Skills**
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

2.2 Collect and collate **information** required to complete tasks

Range:

Information - manufacturer’s instructions, data sheets, building regulations, drawings, BS -EN standards, relevant codes of practice, inspectorate standards.

What do learners need to learn?	**Skills**
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

2.3 Select tools, equipment and materials to complete tasks

What do learners need to learn?

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.

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

What do learners need to learn?

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.

2.5 Analyse formal and informal information to identify potential causes of delays and errors

What do learners need to learn?	**Skills**
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

2.6 Think creatively to adapt designs appropriately to minimise delays and errors

What do learners need to learn?

Engineering situations to suit different environments and un-planned situations, after consultations with site managers and designers, for example where site conditions are different 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.

2.7 Mark out the position of equipment

What do learners need to learn?	**Skills**
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

2.8 Use tools, equipment and materials to carry out **tasks**

Range:

Tasks - installing wiring and containment systems, connecting equipment.

What do learners need to learn?

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

2.9 Install cable containment systems

What do learners need to learn?	**Skills**
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 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

2.10 Install cabling

What do learners need to learn?

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

Suitable means used to identify cables.

2.11 Connect equipment to the installed wiring systems

What do learners need to learn? Connecting/fixing protection system components together using appropriate methods of fixing as listed in the design specification/manufacturers details (call points, detectors, control equipment). with consideration given to material type, materials, and equipment reviewing safety requirements. Appropriate fixings must be used to ensure security of components, and checks should be made to ensure components are level and secure following positioning.	**Skills** MC1

2.12 Terminate and connect cables and conductors

What do learners need to learn?

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

3.1 Prepare for inspection, testing and commissioning

What do learners need to learn?

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

Skills
EC4
EC5

3.2 Inspect protection systems

What do learners need to learn?

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.

3.3 Test protection systems

What do learners need to learn?
Tests to be carried out on electronic protection systems in accordance with relevant current standards and codes of practice, and manufacturers 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

Skills
MC1
MC2
MC4

3.4 Analyse and interpret information and data from ICT applications

What do learners need to learn?	Skills
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

3.5 Adjust protection systems equipment as required by installation standards

What do learners need to learn?	Skills
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

3.6 Complete **documentation** relevant for tasks

Range:

Documentation - system test record, Certificate of Conformance, as fitted document, handover acceptance.

What do learners need to learn?	Skills
Completing all relevant sections/information that must be included on 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, codes of practice.	EC1 EC2 EC3 EC4 DC2

3.7 Use oral and non-verbal communication skills to demonstrate system operation

What do learners need to learn?	Skills
Making reference to O&M manuals as well as manufacturers 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

3.8 Update digital building information management system software and/or O&M manuals

What do learners need to learn?	Skills
Updating relevant system software may include using different types of program (word processing, email, spreadsheets), CAD, PLC’s 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

4.1 Communicate health and safety risks to stakeholders orally

What do learners need to learn?	Skills
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

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

What do learners need to learn?	Skills
Follow correct sequence of activities to complete a maintenance task: • select tools/equipment • obtain method statement/work order • carryout safe and secure isolation (including getting permission to isolate) • remove Isolation • 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 • functional testing	MC10

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

What do learners need to learn?	Skills
Review sequence of maintenance activities as detailed. With application of appropriate timings for each stage. Liaison with stakeholders to agree timings to minimise disruption and enhance safety. Sequence of activities to complete a maintenance task: • select tools/equipment • obtain method statement/work order • carryout safe and secure isolation (including getting permission to isolate) • remove Isolation • 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 • functional testing	MC1 MC2

4.4 Collect system data from ICT applications

What do learners need to learn?	Skills
ICT, including use of computers, digital transmission over IP, email and mobile communication technology for the collection of data and completion of work sheets/maintenance sheets.	MC6 DC4 EC3

4.5 Record system data

What do learners need to learn?	Skills
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

4.6 Test equipment to ensure it is safe to work on

What do learners need to learn?	Skills
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 Vac 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

4.7 Inspect, test and analyse information to identify potential faults

What do learners need to learn?	Skills
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

4.8 Think creatively to propose solutions for installation faults

What do learners need to learn?	Skills
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

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

What do learners need to learn?	Skills
Communicate with stakeholders and obtain necessary permissions to rectify faults, prolong potential faults or 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

4.10 Replace **components** of protection systems

Range:

Components - sensors, detectors, control equipment, signalling equipment, monitoring equipment, power supplies.

What do learners need to learn?

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, and ensuring all work has been recorded or records of work updated including O&M manuals.

Outcome 5 - Decommission protection systems

5.1 Communicate with stakeholders to ensure required information is available to undertake tasks using electronic communication

What do learners need to learn?	Skills
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, PLC's BMS software, and also information relating to both simple and complex systems.	EC1 EC4 EC6 MC7 DC3 DC5

5.2 Make systems safe to work on including safe isolation and discharging stored charge

What do learners need to learn?

Carry out safe isolation procedures and ensure that any charged storage devices such as power supplies are discharged before commencing work on decommissioning.

5.3 Remove protection systems and maintain records

What do learners need to learn?

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

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

Formative assessment – oral Q&A, SmartScreen worksheets (samples available) observation of measuring activities

- Practical - Use of pre-set formative assessments to carry out tasks and record on standardised form.
- Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT

Ways of ensuring content is delivered in line with current, up to date industry practice

- Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes
- Teaching coverage must represent the type of equipment currently available and accepted for use in the UK industry
- Current and emerging testing and programming methods 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
- Closed Circuit Television
  Author: Joe Cieszynski
  Publisher: Newnes; 3rd edition (28 Dec. 2006)
  ISBN-13: 978-0750681629
- Intruder Alarms
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- Electricians Guide to Fire Detection and Alarm Systems
  Author: P. R. L Cook
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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, 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 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 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 protection systems (29%)	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 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, 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
PO4 Maintain protection systems (31%)	T2 Installation, commissioning and decommissioning T3 Carrying out maintenance	Health and safety Systems and components Reports and information	Assessment of risk, PPE, working safely Repair/replace components, use of tools Documentation completion

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***
		Handover and communication Working with faults	Communication with customer to diagnose fault Fault diagnosis, fault rectification
PO5 Decommission protection systems (12%)	T2 Installation, commissioning and decommissioning T3 Carrying out maintenance	Health and Safety Systems and components	Safe isolation procedures Extracting components, handling / disposing of components and materials

358 Refrigeration engineering

Level:	3
GLH-combined with Air conditioning (351):	700
Assessment method:	Practical assignment

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

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

- How does a refrigeration technician minimise the environmental impact of a refrigeration system?
- What are the requirements of the F-Gas regulations?
- What tools and equipment does a refrigeration technician need?

Underpinning knowledge 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:

2. Install refrigeration systems
3. Commission refrigeration systems
4. Maintain refrigeration systems

Completion of this specialism will give learners the opportunity to develop their maths, English and digital skills.

Specialism content

Outcome 1

Common knowledge criteria

1.1 Types of **fluids**

Range:

Fluids - primary refrigerants (CFCs, HCFCs, HFCs, HFOs, HCs, natural), secondary refrigerants (glycols), lubricants (mineral, synthetic), refrigerant vapour/liquid, saturated refrigerant fluids.

What do learners need to learn?

How to identify the refrigerant state at different parts of the system covering saturated, superheated and subcooled conditions using temperature and pressure values around a refrigeration system.

The range of primary refrigerants in use.

The difference between a primary and secondary refrigerant and a mineral and synthetic oil.

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 volume of gases.

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1.2 The safe recovery, recycling and disposal of equipment and hazardous waste transfer

What do learners need to learn?

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 such as oil, ammonia-contaminated water, secondary refrigerants

Safe electrical isolation, and removal and disposal of waste electrical equipment

Regulation and law applicable to waste disposal. Includes the Environmental Protection Act, F-Gas Regulation, and the Waste Electrical and Electronic Equipment (WEEE) regulations.

Mandatory paperwork associated with any hazardous waste transfer and refrigerant recovery.

Legislation, regulations and standards

1.3 Key requirements of **environmental legislation**

Range:
Environmental legislation - Climate Change Act, Control on Ozone-Depleting Substances, F-Gas Regulations, Environmental Protection Act, Hazardous Waste Regulations.

What do learners need to learn?	**Skills**
The key requirements of current environmental legislation and their relation to refrigeration systems. The responsibilities under the requirements of the legislation. 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

Refrigeration systems

1.4 **Processes** of refrigeration cycles

Range:

Processes - temperature scales (Celsius, Kelvin), laws of thermodynamics (first law, second law), heat transfer (conduction, convection, radiation), latent heat processes (melting, fusion, freezing, sublimation, condensation, evaporation, boiling), sensible heat processes (superheating, sub-cooling), evaporation, compression, condensation and expansion processes.

What do learners need to learn?

Celsius and Kelvin temperature scales and their conversion

The laws of thermodynamics and their relationship to the refrigeration system and how heat is transferred (conduction, convection and radiation) to effect latent heat (including sublimation and fusion) and sensible heat processes.

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.

1.5 **Performance parameters** for running a refrigeration cycle

Range:

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

What do learners need to learn?

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) and liquid chillers (utilising low-, medium- and high-temperature secondary refrigerants).

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.

1.6 Refrigeration system **components**

Range:
Components:

- **Compressors** - reciprocating, rotary vane, scroll, centrifugal.
- **Condensers** - air, liquid cooled, evaporative.
- **Evaporators** - forced draft, induced draft, natural convection, liquid cooling, direct expansion, flooded.
- **Expansion devices** - capillary tube restrictor, thermostatic expansion valves (internally and externally equalised), linear/electronic expansion valves, liquid level control.
- **Ancillary components** - liquid and suction line driers, pressure relief valves, strainers, oil separators, moisture indicating sight glass, service valves.
- **Storage vessels** - suction line accumulator, high-pressure receivers.
- **Control valves** - four way reversing, solenoid, evaporator, crankcase, differential pressure regulators, non-return valves.
- **Fans** - axial, propeller, centrifugal.

What do learners need to learn?

The function of a compressor.

The operating principles of reciprocating, screw, rotary, scroll and centrifugal compressors. Their configurations (open, hermetic, semi-hermetic) and typical applications.

The function of a condenser.

The operating principle of air cooled, water cooled, and evaporative condensers as well as their typical applications.

The function of an evaporator.

The operating principles of forced and induced draught, natural convection, and liquid cooled evaporators. Linked to metering devices below, know the difference between flooded and direct expansion feeds to an evaporator.

The function and operating principles of a metering device.

The operating principles of a capillary tube restrictor, thermostatic expansion valve (internal and external equalisation), electronic expansion valve (pulse and linear) and low-side float valve.

The function and operating principles of a variety of ancillary devices including sight glasses, driers (suction and liquid line types), service valves and oil separators.

The function of system storage pressure vessel such as a liquid receiver, a suction accumulator and a surge drum in industrial and commercial systems.

The function and operating principles of four-way reversing valve, solenoid valve, evaporator and crankcase pressure regulators, non-return valves in industrial and commercial systems.

The function and operating principles of axial, propeller and centrifugal fans along with the range of electric motors used to drive them.

1.7 Types of components for **refrigeration systems**

Range:

Refrigeration systems - direct expansion, flooded, pump overfeed, cascade, compound, booster, trans-critical, blast freezing, cold storage, chill storage.

What do learners need to learn?

The different types of components and their suitability in different situations to meet differing client needs.

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.

CO2 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

1.8 The **operating principles** for **defrost systems**

Range:
Operating principles - initiation, termination, defrost sequence.

Defrost systems – off-cycle, electric, hot gas, saturated gas.

What do learners need to learn?

The different types of defrost system used in the refrigeration industry and their control systems.

Why to 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

1.9 Methods to apply **ideal gas laws**

Range:
Ideal gas laws - Boyle’s law, Charles’ law, combined gas law, Dalton’s law.

What do learners need to learn?

Methods to apply the gas laws for common refrigeration operations such as evacuation and pressure testing, and when adaptations to a refrigeration system are needed.

Units of pressure (pascal, bar, millimetres of Hg, torr), pressure scales (absolute, gauge, vacuum).

The gas laws – Boyle’s, Charles’s (Gay Lusak), Dalton’s, and how the combined gas law is derived.

1.10 How to show a **refrigeration cycle** on pressure-enthalpy charts

Range:

Refrigeration cycle - evaporation, compression, condensation, and expansion processes. Refrigeration effect, compressor work done, total heat rejection, dryness fraction, subcooling, useful and non-useful superheat.

What do learners need to learn?

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.

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.

1.11 Interpret refrigeration **data** from pressure-enthalpy charts

Range:

Data - work done, refrigeration effect, total heat rejected, coefficient of performance, mass flow rate, pressure ratio, compressor power input, specific volume at suction, cooling capacity, heating capacity (total rate of heat rejection).

What do learners need to learn?	**Skills**
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. 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

1.12 The **properties** of air and how they are changed by vapour compression systems

Range:

Properties - air temperature, moisture content.

Vapour compression systems - split system for a single room cooling application, fruit and vegetable chill store system, freezer cold room system.

What do learners need to learn?

How a vapour compression system will alter the air temperature and moisture content and the effect this has on the storage of produce.

1.13 **Ideal properties** of **refrigerant fluids** and lubricants

Range:

Primary refrigerant ideal properties - has an odour, non-flammable, non-toxic, miscible with oil, high latent heat value, easily leak detectable, efficient pressure ratio, non-ozone depleting, non-global warming potential, high dielectric strength, high density.

Secondary refrigerant ideal properties - low viscosity, non-toxic, non-flammable, high specific heat value, low cost, non-corrosive, low freezing point

Environmental impact: Ozone depletion, global warming /climate change.

Refrigerant Hazard groups - A, B. 1, 2L, 2, 3.

Ideal properties of lubricants - low floc point, low pour point, low viscosity, high dielectric strength, low foaming tendency, high flashpoint, low hygroscopic effect, low acidity, low moisture content, low toxicity, high miscibility with refrigerant.

Primary refrigerants - HFC, HFO, HC, Natural refrigerants.

Secondary refrigerants - water, propylene glycol, ethylene glycol, brines.

What do learners need to learn?

The ideal properties of a range of primary refrigerants and lubricants and their uses for a range of refrigeration applications.

The ideal properties of a range of secondary refrigerants and lubricants and their uses for a range of refrigeration applications. 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.

The environmental considerations.

1.14 Types of **monitoring systems**

Range:
Monitoring systems - local, remote, building management system (BMS), pack control systems.

What do learners need to learn?

The different types of monitoring equipment and how they can be used to reduce the environmental impact of a refrigeration system. The types of data produced by systems and how the data is produced and extracted. The different types of connectivity available.

Sustainability

1.15 **Environmental impact** of refrigerants

Range:
Environmental impact - F-Gas Regulations, phasedown of refrigerants, effect on global warming /climate change and ozone depletion.

What do learners need to learn?

The environmental impact that different refrigerants have on climate change, their ozone depletion potential (ODP) and their global warming potential (GWP).

1.16 **New developments** in refrigeration

Range:
New developments - low GWP refrigerants (HFO, HC, Natural), safety classifications.

What do learners need to learn?

New developments in the refrigeration industry to reduce the environmental impact of refrigerant gases including using brazed joints and compulsory leak detection.

New refrigerants and their toxicity and fire risks and reduced environmental impact.

1.17 Maximise efficient refrigeration system performance

What do learners need to learn?

Methods to maximise efficiency of a refrigeration system through the selection of refrigerants and components including inverters and PID controllers and setting them up correctly to mitigate direct and indirect carbon emissions

1.18 Fundamental working principles of **electrical controls and components** and **motor starting arrangements**

Range:

Electrical controls - pressure switches, thermostats, flow switches, over current/over temperature (bimetal, PTC, 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).

What do learners need to learn?

The function and operation of the stated electrical controls and components and motor starting systems and their applications.

Specific knowledge criteria for performance outcomes

System Installation (Outcome 2)

1.19 **Methods** for checking refrigeration system leakages

Range:

Methods - strength and tightness testing, use of inert gases, electronic leak detection, leak test fluids, UV dye.

What do learners need to learn?

The methods used to check refrigeration systems for leakages in accordance with the F-Gas Regulations and BS EN 378-2016.

1.20 Types of **substrates**

Range:

Substrates - insulated panels, brickwork, plasterboard, concrete.

What do learners need to learn?

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. The implications for refrigeration system installation.

1.21 Types of **protective materials**

Range:

Protective materials - thermal insulation materials.

What do learners need to learn?

The different types of insulation material used to protect against heat gain/loss. Their properties and how to ensure the material operates effectively.

1.22 Types of **pipework**

Range:

Pipework - copper, steel, aluminium.

What do learners need to learn?

Different types of pipework and their suitability for different purposes.

How pipe characteristics affect refrigerant and oil flow.

1.23 Fix and **terminate cabling**

Range:

Cabling - multi-core flex, steel wire armoured, single conductor, twin and earth, braided sheath cable, screened.

Terminate - insulated crimps, non-insulated crimps.

What do learners need to learn?

The different types of electrical cable used in the refrigeration industry and the methods used to fix and terminate cabling safely.

System commissioning (Outcome 3)

1.24 System operation requirements

What do learners need to learn?

The checks required for commissioning, including after a long period of non-use.

The range of tests and measurements needed to ensure a refrigeration system is operating at maximum efficiency – visual checks, strength test, tightness test, evacuation, charging, system running, measure (superheating, sub-cooling, evaporator air on and off temperature, running currents, refrigerant type and quantity, condenser air on and off) and coil approach temperatures

1.25 **Visual inspection** of a refrigeration system

Range:
Visual inspection - use of human senses (sight, sound, smell, touch).

What do learners need to learn?

Visual inspection of a refrigeration system to determine if any fault conditions are present.

1.26 Expectations of a steady-state operation for refrigeration system

What do learners need to learn?

Expectations of a refrigeration system when it is running at the correct steady-state conditions, including after a long period of non-use. The checks required to confirm expectations include suction and discharge pressures, saturated suction/discharge temperatures, superheating, sub-cooling, storage set-points, running currents, refrigerant charge.

System maintenance (Outcome 4)

1.27 Types of **fault-finding techniques**

Range:

Fault-finding techniques - use of human senses (sight, sound, smell, touch), customer reports, historical records, manifold gauges, electrical test meters, safe electrical isolation.

What do learners need to learn?

Types of fault-finding techniques and diagnostic equipment, and how these are applied to determine a range of mechanical and electrical faults on a refrigeration system. The suitability of different fault-finding techniques for different situations, and how they are applied in practice.

1.28 Cleaning of **components**

Range:

Components - coils, drain pans, drain lines.

What do learners need to learn?

The components that require cleaning and how to clean without compromising the system. The tools, equipment and materials used to clean components - pressure washers and cleaning fluids.

1.29 Disassembly **techniques**

Range:

Techniques - unbrazing, flaring.

What do learners need to learn?

Considerations to safely disassemble a refrigeration system and its components prior to repair or replacement of individual components.

Considerations to include - use of tools, safe electrical isolation, refrigerant recovery. Reference documents to include - manufacturer’s instructions, method statements, risk assessments.

1.30 **Methods** to extract refrigerant

Range:

Methods - recover, reclamation and recycling methods, safe electrical isolation.

What do learners need to learn?

Methods to safely remove refrigerant from a system in accordance with the F-Gas Regulation and all current environmental legislation, Hazardous Waste Regulations. The purpose of Waste Transfer Notes, and methods to safely handle and manage refrigerant once extracted.

Install refrigeration systems – Outcome 2

Performance criteria

2.1 Sequence and prioritise tasks

What do learners need to learn?	Skills
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

2.2 Identify **information requirements** from a brief

Range:

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

What do learners need to learn?	Skills
Identify all the information needed from a range of sources to ensure compliance with local and national by-laws and legislation and any specific manufacturer's requirements.	EC4 EC5

2.3 Gather required **information**

Range:

Information - manufacturer's instructions, non-domestic building services compliance guide, building regulations, local by-laws.

What do learners need to learn?	Skills
Gather all necessary information from a range of sources to ensure compliance with local and national by-laws and legislation and any specific manufactures requirements.	EC4

2.4 Interpret **information and data**

Range:

Information and data - manufacturer's instructions, non-domestic building services compliance guide, building regulations, local by-laws.

What do learners need to learn?	Skills
Interpret all the information gathered to plan the installation of the refrigeration system.	EC4 EC5 MC6

2.5 Calculate **data required**

Range:

Data required - heat gains in cold rooms, product cooling loads, component selection, ideal storage temperatures.

What do learners need to learn?	Skills
Calculate the heat gain into a cold room and determine the product cooling load as well as the ideal storage temperature.	MC2

2.6 Produce written **reports** to stakeholders about work completed

Range:

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

What do learners need to learn?	Skills
Produce written completion documentation for legal compliance (F-gas records) and customer information (operation instructions).	EC1 EC3

2.7 Measure and mark out **installation requirements**

Range:
Installation requirements - pipe routes, location of evaporator coils (coolers), condensing units, services (electricity, gas, water, drainage, ventilation).

What do learners need to learn? Mark out the location of indoor and outdoor sections of the system together with pipe routes for refrigerants, water, drainage and electrical cabling.	**Skills** MC1

2.8 Drill holes for fixings in various **substrates**

Range:
Substrates - insulated panels, brickwork, plasterboard, concrete.

What do learners need to learn? Drill the correct size hole for a range of fixings in a variety of wall materials.	**Skills** MC1

2.9 **Position components**

Range:
Position - levelling, squaring.
Components - coolers, condensers, condensing units, control panels, pipe routes.

What do learners need to learn? Determine the ideal position for the internal and external components with regard to servicing and maintenance requirements and energy efficiency.	**Skills** MC1 MC2

2.10 Insert **protective materials** into drilled holes

Range:
Protective materials - conduits, trunking, fireproof insulation, intumescent mastic.

What do learners need to learn?
To fix protective materials into wall penetrations to prevent collapse and spread of fire.

2.11 Cut **pipework**

Range:
Pipework - copper, steel, aluminium.

What do learners need to learn?
Cut and prepare refrigeration pipework and conduit to required dimensions, ready for connection to other components.

2.12 Manually bend **pipework**

Range:
Pipework - copper, steel, aluminium.

What do learners need to learn?	Skills
Manually bend a range of refrigeration pipes and conduits to suit the installation requirement, to include 90º, 180º and offset bends. Use hydraulic benders to bend larger diameter copper and steel pipes to the same specification as above.	MC1

2.13 Assemble pipework using a range of **forming** and **jointing methods**

Range:
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, Cu/Al joints.

What do learners need to learn?

Join refrigeration pipework and components using brazing, flaring and swaging methods (Cu to Cu, Cu to Fe, Cu to brass, Fe to brass). Purging using oxygen-free nitrogen (OFN) to prevent internal scaling. How to protect components from heat damage while brazing, and the application of pipe insulation materials.

Purging – use of OFN.

System components – condensing units, evaporators, condensate drains, valves, electrical cabling, drier, pressure switches, pumps, sight glass, vessels.

Fixing – vibration damping clamps, pipe saddles, pipe clips, insulated clamps.

Protective measures – wet rag, non-conductive foam, temporary removal of low melting point items.

Temperature-sensitive system components – thermostatic expansion valves, solenoid valves, vibration eliminators, Schrader valves, pressure transducers.

2.14 Permanently fix indoor and outdoor units

What do learners need to learn?

Permanently fix a range of refrigeration components and supports including pipework and cabling to different wall, ceiling and floor materials, insulated panels, brickwork, plasterboard, concrete.

2.15 **Leak test** system inert gas

Range:

Leak test - strength and tightness testing, pressure testing using inert gas, soap solutions, proprietary leak test solutions.

What do learners need to learn?

Leak test a refrigeration system in accordance with the requirements of the F-Gas Regulations using inert gases prior to commissioning.

Outcome 3 - Commission refrigeration systems

3.1 Interpret a risk assessment

What do learners need to learn? Interpret risk assessments with consideration given to responsibilities, persons at risk, and applying controls, recording potential hazards and completion of documentation.	**Skills** EC4 EC5

3.2 Interpret **information** provided

Range:
Information - BS EN378, F-Gas Regulations, contractual specifications, manufacturer's instructions, including tabular and graphical information.

What do learners need to learn? Interpretation of regulatory, contractual and manufacturer's specifications and requirements in readiness to carry out system commissioning.	**Skills** EC4 EC5

3.3 Collect **data** from control system

Range:
Data - superheat, subcooling, coil approach temperature (Delta T), air flow, air distribution, air on and off temperature, oil pressure, system running pressures, running current, relative humidity, primary and secondary refrigerant flow rates, temperature set-points.

What do learners need to learn? Access the system and its controls to collect a range of data.	**Skills** MC5 MC6 DC4

3.4 Interpret commissioning **data** collected

Range:
Data - superheat, subcooling, coil approach temperature (Delta T), air flow, air distribution, air on and off temperature, oil pressure, system running pressures, running current, relative humidity, primary and secondary refrigerant flow rates, temperature set-points.

What do learners need to learn? Interpret recorded data to ensure the design conditions and parameters are met.	**Skills** MC6 DC4 EC5

3.5 Discuss **requirements** with stakeholders

Range:

Requirements - product load, types of product stored, required storage temperatures, access and usage.

What do learners need to learn?	**Skills**
Use open questioning and listening techniques to ensure that the end user's/client's requirements and needs are met.	EC2 EC4 EC5 EC6

3.6 Inspect system installation

What do learners need to learn?

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.

3.7 Establish a **steady-state** operation

Range:

Steady state - storage temperatures, operating pressures, superheat, subcooling, running current, air flow rates.

What do learners need to learn?	**Skills**
Use commissioning instruments to collect and record data such as temperatures, systems pressures, flow rates and running currents. Interpret the data readings recorded to ensure that the steady-state conditions achieved meet the contractual requirements.	MC6 DC3

3.8 **Adjust** system for optimum performance.

Range:

Adjust - storage temperature, safety controls (high and low pressure), air flow rates, head pressure controls, position of sensors, energy efficiency.

What do learners need to learn?	**Skills**
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.	MC6

3.9 Record **test results**

Range:

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

What do learners need to learn?	Skills
Record all commissioning data and set-points in accordance with the client’s requirements, F-Gas Regulations and future reference (service activities).	EC3

Outcome 4 - Maintain refrigeration systems

4.2 Produce a **method statement**

Range:

Method statement - scope of works, manufacturer's instructions, contractual requirements, risk assessment, preventative or reactive maintenance, permits to work.

What do learners need to learn?	**Skills**
Produce a method statement and risk assessment for either preventative or reactive maintenance through interpretation of system data, customer reports or contractual requirements.	EC1 EC2 EC4

4.3 Assess suitability of **information** provided

Range:

Information - sufficiency, accuracy, currency, previous service records, F-Gas records, customer, senses, site logs.

What do learners need to learn?	**Skills**
Consider all of the information available with regard to its accuracy and reliability before creating a maintenance plan.	EC4 EC5

4.4 Calculate **resource requirements**

Range:

Resource requirements - refrigerant type and quantity, lubricants, cleaning agents, spare parts, consumables.

What do learners need to learn?	**Skills**
Consider the maintenance plan and manufacturers instruction to calculate and compile a list of all materials needed to complete the maintenance task.	MC2 EC3

4.5 Produce **technical reports**

Range:
Technical reports - maintenance reports, maintenance plans and schedules, site logs, F-Gas records.

What do learners need to learn?	**Skills**
Complete service and maintenance site reports on work carried out and update site logs and F-Gas records.	EC3

4.6 Visually inspect the system

What do learners need to learn?

Carry out a visual inspection of the system first, with consideration given to health and safety and possible faults that may not be apparent to the client/customer. Visual inspection to include security of pipework, vibration mounts, corrosion, refrigerant or water leaks, mechanical damage, loose screws or connectors.

4.7 Clean **system**

Range:
System - evaporator and condenser coils, air filters, water filters, drain pans, drain lines, unit casings.

What do learners need to learn?

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

4.8 Extract **components** from the system.

Range:
Components - compressors, driers, fan motors, defrost heaters, expansion devices, refrigerants, solenoid valves, pressure control valves.

What do learners need to learn?

Remove and replace a variety of components from a refrigeration system ensuring all health and safety and environmental considerations are followed.

4.9 Apply **fault-finding techniques** to identify faults

Range:

Fault-finding techniques - data analysis, leak-testing, operational logs, F-Gas records.

What do learners need to learn?	Skills
Apply a range of fault-finding techniques such as data analysis, observation of running conditions, and review of operation logs and past service reports to identify a range of mechanical and electrical faults.	MC2 MC6 DC4 EC5

4.10 Rectify **faults**

Range:

Faults - poorly fitted insulation, broken or blocked condensate drain, incorrectly set controls, component failure.

What do learners need to learn?
Replace or repair a range of system faults and components to return a refrigeration system to full operational condition.

4.11 Report on maintenance concerns

What do learners need to learn?	Skills
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

4.12 Classify **waste** for disposal and recycling

Range:

Waste - refrigerants, lubricants, pipework, valves, driers.

What do learners need to learn?
Identify a range of waste materials produced during a service and maintenance activity in accordance with the Hazardous Waste Regulations and the F-Gas Regulations.

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, SmartScreen worksheets (samples available) observation of measuring activities

  - Practical - Use of pre-set formative assessments 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 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 - **www.gov.uk/government/collections/fluorinated-gas-f-gas-guidance-for-users-producers-and-traders**
- F-Gas **www.refcom.org.uk**

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

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 a plumbing 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 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 component,
	T1- Design T3 – Install and commission	Reports and information	Interpretation of drawings, specifications, 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 Risk assessment, working safely, PPE

	T3 – Install and commission T3 – Install and commission T3 – Install and commission T4 – Carry out service and maintenance	Health and Safety Reports and information Handover/ communication	Commissioning records Handover to customer
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

359 Ventilation

Level:	3
GLH – Combined with 355 Heating	765
Assessment:	Practical assignment

What is this specialism about?

The purpose of this specialism is for learners to understand and undertake fundamental ventilation work. Learners will have the opportunity to plan, perform and evaluate their work 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 ventilation installation work
- Technical terms, data and units of measurement in ventilation systems design and installation
- Ventilation systems and their purpose (mechanical and natural ventilation)
- Ventilation systems tools, equipment and controls
- Ductwork materials (metal and non-metal) fittings, installation processes and jointing methods

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

- What kind of tasks are carried out by a ventilation system installer?
- What types of systems does a ventilation installer work on?
- What tools and equipment are used by a ventilation installer?

Underpinning knowledge outcome

On completion of this specialism, learners will understand:

1. Ventilation knowledge criteria

Performance outcomes

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

2. Install ventilation systems
3. Commission ventilation systems
4. Maintain ventilation systems

Completion of this specialism will give learners the opportunity to develop their maths, English and digital skills.

Specialism content

Outcome 1

Common knowledge criteria

Health and safety

1.1 **Typical hazards** and **safe systems** of work specific to ventilation engineering

Range:

Typical hazards - legionnaires disease**,** asbestos, working at height, manual handling.

Safe systems of work - risk assessment, method statement**,** safe isolation techniques.

What do learners need to learn?	**Skills**
The different controls that need to be in place to minimise hazards occurring. Safe use of electrical equipment and how to prevent electrocution. Roles and responsibilities for safety under relevant legislation, codes of practice and permits to work. Implications of poor health and safety performance: indoor air quality (IAQ), dust, contaminants, odours.	EC5

Ventilation systems

1.2 Types of **systems**

Range:

Systems - mechanical ventilation, natural ventilation, mixed mode ventilation, mechanical ventilation with heat recovery (MVHR), supply, extract, local exhaust ventilation (LEV), kitchen extract, fire and smoke.

What do learners need to learn?

The types of ventilation systems used in buildings (domestic, industrial, commercial, education, health care, leisure sector and community buildings).

The basic functions, and typical environments of occupied spaces in buildings (kitchens and bathrooms in housing, manufacturing spaces in factories, open plan offices in commercial buildings).

Variations for special environments (cleanrooms, hospital operating theatres, scientific laboratories, swimming pools, toilet extracts) and key considerations for energy efficiency, installation and maintenance.

Their purposes, similarities and differences in operation.

1.3 Mechanical components

Range:

Mechanical components - fans, filters, dampers, air-to-air heat exchangers, fire dampers, air handling units (AHUs), fan coil units (FCUs), variable air volume (VAV).

What do learners need to learn?

The different mechanical components used in ventilation engineering systems.

Their function and performance characteristics and the implications for the system of component failure.

1.4 Electrotechnical components

Range:

Electrotechnical components - inverters, actuators, sensors, motors.

What do learners need to learn?

The types of electronic components used in ventilation engineering systems: thermostat, humidistat, anemometer, manometer.

Their function and performance characteristics.

The implications to the system of component failure.

1.5 Types of **control system**

Range:

Control system - Building management system (BMS), stand alone, time clock, manual on/off.

What do learners need to learn?

The types of controls required in ventilation engineering systems. The purpose of different controls, their components, similarities and differences and efficiencies.

1.6 The importance of system cleanliness

What do learners need to learn?

The importance of system cleanliness.

Cleanliness industry standards and guidance.

The methods used to achieve system cleanliness pre and post installation.

The implications for system performance and the health and wellbeing of building occupants of poor cleanliness standards in ventilation systems.

1.7 Tools, equipment and **materials**

Range:

Tools - power tools**,** hand tools.

Equipment - portable access equipment, anemometer, flow meter, temperature sensors, bolometer (flow hood).

Materials - rigid**,** semi-rigid**,** flexible**,** thermal insulation, jointing compounds, seals and tape.

What do learners need to learn?

Common equipment, tools and materials, and their purpose.

1.8 Operation and handling requirements

What do learners need to learn?

The importance of protecting ventilation system components (ductwork) during delivery from a manufacturer (fabrication location) and others in the supply chain to a site delivery address (pre-delivery and installation (PDI) levels). The importance of correct Onsite storage and handling.

1.9 Types of ductwork and in-line system components and their suitability for different systems

What do learners need to learn?

The types of ductwork and in-line system components, their function and technical performance characteristics.

The nature of the environment and its effect on ductwork and components, IP ratings of electrical components, corrosion of metallic elements, durability of plastic, flexible and fabric ductwork.

1.10 Types of linings, coatings and identification labels

What do learners need to learn?

The types of ductwork linings and coatings.

Their characteristics and use for different purposes/applications and suitability for different systems.

The purpose of identification labels.

1.11 Types of ductwork **materials**

Range:

Materials - rigid**,** semi-rigid**,** flexible**,** fabric.

What do learners need to learn?

The range and types of ductwork materials, their function and technical performance characteristics (strength and durability).

Materials = metals, plastics, fabrics.

Their use in domestic and non-domestic buildings (industrial, commercial, education, health care, leisure sector and community buildings).

Their use in specialist situations such as swimming pools.

Their properties (fire ratings, thickness gauges) and suitability for different systems.

1.12 Types of **thermal insulation materials**

Range:

Thermal insulation materials - rockwool insulation, phenolic insulation.

What do learners need to learn?

The types of ductwork thermal insulation materials, their function and technical performance characteristics (thermal conductivity, thermal resistance). Their properties and suitability for different systems.

1.13 Types of **support**

Range:

Support - fittings (clips, brackets), fixings (uni-rail, threaded bar).

What do learners need to learn?

The types of ductwork fittings and fixings for structural integrity.

Their function and technical performance characteristics (tensile strength, maximum load) and their suitability for different systems.

Information and data

1.14 Asbestos register and legionella control logbook

What do learners need to learn?

Systems of recording information and data related to safety.

The contents and importance of the asbestos register and legionella control logbook.

Methods of minimising sources of other airborne contaminants.

1.15 Indoor air quality requirements for different situations

What do learners need to learn?

The requirements for indoor air quality for different building situations (domestic, industrial, commercial, education, health care, leisure sector and community buildings) to ensure health and wellbeing for building occupants.

The air quality for typical environments of occupied spaces in buildings (bathrooms, toilets, kitchens, offices, classrooms, hotel rooms) as well as variations for special environments (hospital operating theatre, museums, computer chip manufacturing, data centres, pharmaceutical manufacturing, food manufacturing).

1.16 Types of **documentation** produced

Range:

Documentation - commissioning certificates, manufacturer's data sheets, asset lists, as built drawings.

What do learners need to learn?	**Skills**
Types of documentation, their content and purpose. Quality assurance (QA) systems for documentation. The importance of file management, file sharing and specific document version control.	EC3 EC5 DC5

Specific knowledge criteria for performance outcomes

System commissioning (Outcome 3)

1.17 Positive and negative pressure classification, airtightness, and system balancing

What do learners need to learn?

Ductwork operating pressures.

Integrity of ductwork and acceptable leakage rates.

Positive and negative pressure ventilation systems.

1.18 Types of **checks** and **tests**

Range:

Checks - visual inspection (system integrity, system cleanliness).

Tests - system balance, set to work, air flows, volume, pressure, temperature, BMS point-to-point and functional tests, post clean vacuum testing.

What do learners need to learn?

Types of checks and tests, their purpose and the techniques to be applied.

The importance of completing commissioning checks and procedures.
Commissioning and testing principles for ventilation ductwork, mechanical fans and natural ventilation systems.

Relevant testing and commissioning references, building regulations Approved Document F (fan flow rate testing), DW/111 or BSRIA BG19 (ductwork systems testing) and BSRIA TN 11/95 (natural ventilation design).

Testing methods and instrumentation for mechanical ventilation flow rates.

Natural ventilation design strategies and post-construction testing (single sided, crossflow, stack effect and atria designs).

System maintenance (Outcome 4)

1.19 Cutting techniques

What do learners need to learn?	Skills
The common tools, equipment and materials needed for cutting sections of ventilation ductwork.	MC1

1.20 Mechanical joining techniques

What do learners need to learn?

The common tools, equipment and materials needed for joining sections of ventilation ductwork.

1.21 Assembly and disassembly techniques

What do learners need to learn?

The access equipment for safely assembling and taking apart ductwork sections.

1.22 Fault-finding

What do learners need to learn?	Skills
Fault-finding techniques (electronic sensors sending signals to a BMS indicating a fault on supply or extract ductwork flow rate, air pressure, temperature or humidity, power failure). Unusual reading of CO_2 concentration in a room or building zone or operational faults in mechanical fans, at supply or extract grilles or exhaust outlets. How fault-finding techniques are applied and their suitability for different situations.	MC1 MC2

1.23 Waste management of decontaminated ductwork

What do learners need to learn?

Maintenance best practice related to cleanliness and hygiene of ventilation systems.
Regulations, procedures and guidance for ensuring the cleanliness of ventilation systems (air handling units, ductwork, fans, filters and all other associated components in ventilation systems).

The Building Engineering Services Association (BESA formerly the HVCA) publication TR/19 (Guide to Good Practice: Internal Cleanliness of Ventilation Systems).
The relevant regulations included in the Workplace (Health, Safety and Welfare) Regulations 1992.

Regulation 6 Ventilation: important aspects are dirt, dust, grease, and other contaminants in ventilation ductwork systems.

Outcome 2 - Install ventilation systems

Performance criteria

2.1 Interpret a risk assessment

What do learners need to learn?	**Skills**
Review and assess any work task for its risk to health and safety with consideration given to HSE guidelines. The Construction (Design and Management) (CDM) Regulations and the responsibilities of all employers and employees. Apply safety controls where identified by a risk assessment. Review and adjust a risk assessment where necessary. Consider COSHH in relation to extension of existing systems.	EC4 EC5

2.2 Interpret **information** provided

Range:

Information - specification, drawings, locations of in-duct temperature and humidity sensors, local site considerations.

What do learners need to learn?	**Skills**
Interpret information needed to install ventilation systems. Use specifications and plan layout drawings to identify ductwork routes and location of components. Create a materials list as required.	EC5

2.3 Calculate **installation requirements**

Range:

Installation requirements - thermal comfort of building occupants, supply ventilation volumes, extract ventilation volumes, flow rates, mechanical ventilation, natural ventilation, positive and negative static pressure, ductwork dimensions, ductwork fittings pressure loss, duct route lengths, fan specification, air velocity, velocity pressure (VP), structural load bearing, necessary fixings and support tolerances, window opening sizes for natural ventilation air flow.

What do learners need to learn?	**Skills**
Determine ventilation installation requirements in a range of building types (domestic, industrial, commercial, education, health care, leisure sector and community buildings). Calculate installation requirements.	MC1 MC2 MC6

2.4 Measure **ductwork requirements**

Range:

Ductwork requirements - ductwork route lengths**,** locations of fixings**,** locations of components, accessibility of components.

What do learners need to learn?	**Skills**
Measure ductwork route lengths, dimensions, fitting space and the locations of all ventilation components (fans, dampers, silencers, diffusers, inlet and extract grilles). The use of access equipment to measure ductwork.	MC1

2.5 Mark out required measurements

What do learners need to learn?	**Skills**
Measure positions in the building for the locations of ductwork fixings, routes and components to include on the building fabric (wall or ceiling) and on ductwork. .	MC1

2.6 Prepare work areas for installation activities

What do learners need to learn?

Prepare the work area appropriately and safely for all ventilation system ductwork and components by ensuring:

- necessary access and space requirements to build a safe working platform
- necessary lighting for the work tasks (general area lighting and task-specific spotlights)
- necessary power for the work tasks equipment (power drills, ductwork cutting tools)
- correct PPE
- all aspects of toolbox talks are considered.

2.7 Position, fix, insert and secure ventilation ductwork

What do learners need to learn?

Fixing procedures and tasks including various types of bearers and hangers for ductwork.

Install rectangular, circular, rigid, semi-rigid, flexible and fabric ducting.

Install steel and aluminium ducting. Install ventilation ductwork components (fans, dampers, silencers, diffusers, inlet and extract grilles).

2.8 Test for air leakages and make corrections

What do learners need to learn?	**Skills**
Test for airtightness (air leakages in ductwork) to ensure the integrity of the system and its air flow performance, in accordance with DW143. Carry out airtightness tests for ductwork. Note the location of any ductwork air leakages for a repair and maintenance plan. Rectify and re-test.	MC1

2.9 Update digital building information management system software

What do learners need to learn?	Skills
Record and update all digital building information management system software when new ventilation ductwork and components have been installed.	DC1 DC2 DC3 DC5 DC6

Outcome 3 - Commission ventilation systems

3.1 Assess risks associated with completing activities

What do learners need to learn?	**Skills**
Produce, review and/or adjust risk assessment for commissioning tasks. Complete commissioning and testing method statement. Produce a risk assessment and method statement for ventilation system commissioning activities in accordance with the five stages of risk assessment: • Identification of hazards (working at height, working on a temporary work platform including a scaffold tower (medium risk) or step ladder (high risk) • Identification of who is at risk and how • Assessment of risk and action • Recording of findings • Review of risk assessment • Method statements for work activities should be prepared to ensure that all commissioning technicians work to the same sequence and procedure, using the same tools and equipment and work in pairs or teams where required for safe working.	EC1 EC2 EC3 EC4

3.2 Assess suitability of information provided

What do learners need to learn?	**Skills**
Carry out commissioning tests to provide to the building owner or facilities management team full and accurate records of the performance of the installed ventilation system. • Assess all essential commissioning and testing information for the installed system. • Prepare commissioning and testing checklist in a logical sequence for the site. • Complete commissioning records for the site. • Confirm testing instrumentation accuracy (calibration). • Record all results accurately (operator).	EC1 EC3 EC5 MC2 MC6 DC5

3.3 Interpret collected data

What do learners need to learn?	Skills
Carry out preliminary checks of the building construction and the ventilation system to make sure they are at a point that is appropriate for commissioning and testing to take place, checking that the ductwork is complete and meets required air leakage limits (pressure testing), and is at a standard of cleanliness that is appropriate for the commissioning stage. Accurately interpret all ventilation system performance targets and actual test results and compare the two data sets to record if the actual results are within expected tolerances.	EC5 MC6

3.4 Test system

What do learners need to learn?	Skills
Carry out a testing and commissioning procedure for a ventilation system and its components. Switch on fan, initially running at less than full speed, checking for no excessive vibration or noise and no overheating of the fan motor, then at full speed. • Set ventilation ductwork dampers to the correct position for the test (all fully open). • Switch on fan and allow it to run. • Check fan operation is correct. • Check initial air volume flow rate and fan pressures. • Record air volume flow rates (for comparison to design performance targets). • Regulate air flow rates (system balancing). Test actuators for automatic window opening and automatic damper operation in a natural ventilation system.	MC1 MC10

3.5 Record test results

What do learners need to learn?	Skills
Record performance test results in the system checks, including test results for air volume flow rates and for various fan static pressures.	EC1 EC3 EC4

3.6 Annotate system profile and layout drawings reflecting system adaptions

What do learners need to learn?	**Skills**
Annotate all system drawings and specifications to show fans and other system components. Information - fan pressure, volume flow rates delivered, motor current at various fan speeds, air temperature and humidity (psychrometry), component identification reference numbers, main ducts and branch duct routes, terminals - types and locations and their air flow rates, controller test results for various set-points. Test results information to be annotated in schematic and layout drawings.	MC7

3.7 Update building information systems

What do learners need to learn?	**Skills**
Update the building information system after the testing and commissioning have been completed.	DC1 DC2 DC3 DC4 DC5

3.8 Produce handover documentation

What do learners need to learn?	**Skills**
Prepare all handover documentation for client/end user. Agree format for commissioning documentation appropriate for the building design and site location. Produce site asset list (ventilation system component, reference number, manufacturer, model, site location). Record notes on visual checks and preliminary checks in handover documentation. Record design performance and actual performance test results in handover documentation. Hand over to customer/end user. Communicate system information, demonstration and maintenance requirements to customer.	EC1 EC2 EC3 EC4 EC6

Outcome 4 - Maintain ventilation systems

4.1 Sequence and prioritise tasks

What do learners need to learn?

Carry out tasks for both emergency maintenance and planned maintenance. Respond quickly to emergency maintenance (an alert from BMS or client's needs).

React to and prioritise tasks depending on how critical the maintenance is.

Carry out planned maintenance with consideration for the client's needs to minimise any inconvenience.

Plan tasks using a maintenance schedule.

4.2 Identify information requirements

What do learners need to learn?	Skills
Identify and correctly interpret maintenance needs in ventilations system for both planned and emergency maintenance. Emergency maintenance could include, fan failure, temperature, humidity, CO_2 sensor readings not being what they should be or ductwork damage being visible (flexible ducting tear / puncture). Planned maintenance could include, filter replacements, ductwork cleaning and visual inspection.	EC4 EC5 MC1 MC2 MC6

4.3 Gather required **information**

Range:

Information - component manufacturer specifications for recommended maintenance requirements**,** commissioning and testing handover documentation**,** site registers**,** as-built schematic and layout drawings.

What do learners need to learn?	Skills
Gather all necessary information required for a maintenance task, including component manufacturer's specifications or commissioning and testing handover documentation.	EC4 EC5

4.4 Calculate maintenance downtime

What do learners need to learn?	Skills
Plan maintenance work schedules appropriately to minimise the system downtime in a building location with consideration given to downtime estimate for system maintenance, appropriate work planning schedule (weekends or night hours, appropriate site access arrangements).	MC2

4.5 Convert imperial **measurements** to metric

Range:

Measurements – air flow rates, air pressure, fan diameter, fan specification.

What do learners need to learn?	Skills
Convert imperial measurements to metric, for example - fan performance air flow rates in m^3/s, m^4/h and in cubic feet per minute (cfm).	MC1 MC4

4.6 Calculate resource and equipment requirements

What do learners need to learn?	Skills
Plan maintenance work schedules appropriately to make sure that all necessary resources for a maintenance task are in place. Estimate and calculate required human resources, materials, tools and equipment for the system maintenance.	MC1 MC2 EC5

4.7 Discuss with the client the effectiveness and efficient status of the installation

What do learners need to learn?	Skills
Use open questioning and listening techniques to establish client needs with regard to the effectiveness of the ventilation system and adjust and adapt set points if necessary, to meet customer needs.	EC1 EC6

4.8 Clean system including pre-and post-clean testing

What do learners need to learn?

Access and clean ventilation system ductwork and components (supply and extract grilles, fan motor casings, fan blades, filters, dampers).

Remove dust and other debris from all parts of a ventilation system to ensure it operates to its full performance level.

Clean ductwork and components in-situ or remove for cleaning and replacement.

4.9 Handle all **materials** correctly and in a safe way

What do learners need to learn?

Handle materials to maintain their integrity and that of the system.

4.10 Identify root cause of **faults**

Range:

Faults - ventilation system component failure**,** heating chilled water system component failure.

What do learners need to learn?	**Skills**
Respond to sensor alarms and building management system control panels to identify and understand the cause of ventilation system faults.	MC2 MC10

4.11 Apply **fault-finding techniques** to rectify system operation

Range:

Fault-finding techniques - visual checks, performance testing, check operation of heating and cooling coils.

What do learners need to learn?	Skills
Inspect faults in the ventilation system through visual checks and performance testing. Faults could be identified by electrical power failure, mechanical component failure (grilles, filters, or dampers not opening and closing properly or a ducting rupture (rigid, semi-rigid or flexible)). Use fault-finding techniques to rectify fault and repair system operation. Inform responsible personnel of heating, cooling or electrical faults.	MC2 EC1 EC6

4.12 Measure **ductwork dimensions**

Range:

Ductwork dimensions - rectangular ductwork dimensions, circular ductwork dimensions, oval ductwork, fitting into building spaces, transformation sections (expansion and contraction).

What do learners need to learn?	Skills
Correctly measure ductwork dimensions: length, breadth, rectangular perimeter, circular circumference, diameter, radius and cross-sectional area.	MC1

4.13 Cut **ductwork**

Range:

Ductwork - rigid, semi-rigid, flexible.

What do learners need to learn?	Skills
Use tools and equipment correctly, to cut ductwork.	MC1

4.14 Join ductwork using mechanical **techniques**

Range:

Techniques – frames, slip joints.

What do learners need to learn?	Skills
Use methods and techniques to join ductwork sections together.	MC1

4.15 Disassemble parts of a system

What do learners need to learn?

Access ductwork sections for their removal (rigid, semi-rigid and flexible ductwork sections).

Follow disassembling procedures by completing isolation of system/system part before disassembly.

Use suitable access equipment where necessary.

4.16 Reinstall **components** within a system

Range:

Components - ductwork sections, supply and extract grilles, fan motor casings, fan blades, filters and dampers.

What do learners need to learn?

Access ductwork components for their replacement (re-installation).

Re-install components in a ventilation system.

Use suitable access equipment where necessary.

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
- Environmental impact
- Construction information and data principles – Standards, regulations and guidance
- Health and safety - BSE Regulations and safe working practices
- Building Services Engineering (BSE) systems
- 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

Considerations for innovative methods of delivery to include blended learning and other forms of technology,
Innovative methods of delivery could include:

- Blended learning throughout theory and practical to contextualise learning – using measurements and calculations (room dimensions and volume, room type, estimated occupancy, air supply and/or extract requirements, fan size, duct size and grille size)
- Natural ventilation - survey work for openable windows for cross flow, single sided or stack natural ventilation
- Use different rooms in a building for questioning i.e. – would this room be suitable for natural ventilation?
- Comparison of calculated data to actual data (measured)
- CIBSE guide B – why would different building types have different ventilation requirements? (group debates/ discussions)

Formative assessment – oral Q&A, SmartScreen worksheets (samples available) observation of measuring activities

- Practical - Use of pre-set formative assessments carry out tasks and record on standardised form.
- Knowledge – pre-set paper-based activity to confirm skills and understanding. Learners can use variety of methods to carry out activities, calculators, apps, office IT

Ways of ensuring content is delivered in line with current, up to date industry practice

- Centres will need to ensure a realistic representation of ventilation systems and components
- Centres will need to provide the appropriate tools, equipment and test instrumentation for demonstration and practical training purposes

    - The provision must represent the type of equipment currently available in the UK ventilation industry
    - New and emerging ventilation systems, tools, components and technology should be included in delivery e.g. MVHR Mechanical Ventilation with Heat Recovery.

Suggested learning resources

Books/documents

- BSRIA the illustrated guide to ventilation
- CIBSE Natural Ventilation AM10
- CIBSE Mixed Mode Ventilation AM13
- CIBSE Guide B Heating, ventilating, air conditioning and refrigeration
- CIBSE Guide F Energy efficiency in buildings
- Building Regulations App Doc F - **Building Regulations App Doc F**
- BSRIA guide – The rules of thumb (BG9)

Websites

- FläktWoods **https://www.flaktgroup.com/uk/products/air-movement/ventilation- fans/**
- Vent Axia **https://www.vent-axia.com/**
- Monsoon **https://www.nationalventilation.co.uk/**
- **www.air-source.net**
- **www.bsria.co.uk**
- **www.CIBSE.org**
- **www.barkell.co.uk**
- **www.ke-fibretec.com**

Scheme of Assessment – Ventilation

The Ventilation engineering occupational specialism is assessed by one practical assignment. The duration of the assessment is 20 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 ventilation 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	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. 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 ventilation systems (44%)	T1 – Plan the installation T2 – Install and commission T1 – Plan the installation T2 – Install and commission T1 – Plan the installation	Health and Safety Design and Planning Measure and mark out Installation of systems and components Reporting and information	Risk assessments, PPE, Working safely Method statements, installation diagrams, material lists, selecting types of systems and components, measuring and marking out., installation requirements and calculations Measure and mark out ductwork requirements Using tools and equipment, cutting and bending ductwork, jointing methods, positioning and securing components. Interpretation of drawings, specifications, manufacturer instructions

		Inspecting and testing systems and components	Air leakage tests,

PO3 Commission ventilation systems (23%)	T2 – Install and commission	Inspecting and testing systems and components Health and Safety Reporting and information Handover/ communication	Commissioning checks and tests Risk assessment, working safely, PPE Commissioning records Hand over to customer

PO4 Maintain ventilation systems (33%)	T3 – Carry out maintenance activity	Health and safety	Risk assessment, working safely, PPE
		Working with faults	Fault diagnosis, client requirements, conversion of measurements, Repair and replace components, use of tools
		Installation of systems and components	Measure, cut and join ductwork
		Documents	Materials list, method statement
		Reports and information	Maintenance report
		Handover/ communication	Communication with customer to diagnose fault

Appendix 1 Sources of general information

The following documents contain essential information for Providers delivering City & Guilds T Level Technical Qualifications. They should be referred to in conjunction with this specification and the Provider approval and quality assurance information.

You can download these from **www.cityandguilds.com**.

Centre Contract General Terms
Quality Assurance Standards: Centre Handbook
Quality Assurance Standards: Centre Assessment

Within these documents you will find information in relation to;

- centre assessment,
- internal quality assurance (IQA),
- IQA strategy,
- alternative locations and subcontractors,
- non-compliance,
- malpractice, and
- centre support roles and resources

All T Level providers must ensure they familiarise themselves with the above documents and adhere to the general terms as part of their conditions of approval.

Useful contacts

UK learners General qualification information	**E: learnersupport@cityandguilds.com**
International learners General qualification information	**E: intcg@cityandguilds.com**
Centres Exam entries, Certificates, Registrations/enrolment, Invoices, Missing or late exam materials, Nominal roll reports, Results	**E: centresupport@cityandguilds.com**
Single subject qualifications Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change	**E: singlesubjects@cityandguilds.com**
International awards Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports	**E: intops@cityandguilds.com**
Walled Garden Re-issue of password or username, Technical problems, Entries, Results, e-assessment, Navigation, User/menu option, Problems	**E: walledgarden@cityandguilds.com**
Employer Employer solutions, Mapping, Accreditation, Development Skills, Consultancy	T: +44 (0)121 503 8993 **E: business@cityandguilds.com**

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Get in touch

The City & Guilds Quality team are here to answer any queries you may have regarding your T Level Technical Qualification delivery.

Should you require assistance, please contact us using the details below:

Monday - Friday | 08:30 - 17:00 GMT

T: 0300 303 53 52

E: **technicals.quality@cityandguilds.com**

W: **www.cityandguilds.com/tlevels**

Web chat available **here**.

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