

Unit 16: Mechanical and Electrical Services in Construction

Unit code:	H/600/0229
QCF Level 3:	BTEC Nationals
Credit value:	10
Guided learning hours:	60

● Aim and purpose

This unit provides an understanding of mechanical and electrical building services, specifically for learners following a construction pathway. They will explore the provision of hot and cold water systems, electricity, gas and drainage to low-rise buildings.

● Unit introduction

The provision of high quality mechanical and electrical building services is essential in the modern world. Building services supply buildings with cold water that is safe to drink, and the means to heat that water. They dispose of surface and foul water and provide power for a variety of electrical systems and gas appliances.

They do this so effectively that we tend to take them for granted, at least until something goes wrong. It is the provision of high quality building services that differentiates modern buildings from those constructed in previous times.

A builder must provide the structure that the building services will function within. Builders must therefore have a basic understanding of building services, so that they can contribute to the effective integration of these services into buildings.

Learners will acquire a basic knowledge and understanding of the provision of building services from the perspective of a builder. This will include hot and cold water systems, drainage facilities and the supply of single phase electricity and gas.

● Learning outcomes

On completion of this unit a learner should:

- 1 Understand the principles and practices associated with the provision of hot and cold water systems to buildings
- 2 Understand the principles and practices associated with the provision of above and below ground drainage systems to buildings
- 3 Understand the principles and practices associated with the provision of simple single-phase electrical systems to buildings
- 4 Understand the principles and practices associated with the provision of gas supplies to buildings.

Unit content

1 Understand the principles and practices associated with the provision of hot and cold water systems to buildings

Provision of cold water systems: distribution of cold water to and in homes; comparison of direct and indirect systems; layouts; specifications; dimensions; capacities; materials used

Provision of hot water systems: provision and distribution of hot water in homes; comparison of direct and indirect systems; layouts; specifications; dimensions; capacities; materials used

2 Understand the principles and practices associated with the provision of above and below ground drainage systems to buildings

Provision of above ground drainage: requirements of systems eg water seal, prevention of disruption of water seal by siphonage, need for ventilation; effect on design of systems; comparison of single-stack and two-pipe systems; layouts; dimensions; specifications; materials used

Provision of below ground drainage: requirements of systems eg capacity, fall, ventilation, support, access for maintenance and repair, shortest possible pipe runs; effect on design of systems; separate and combined systems for surface and foul water; layouts; dimensions; specifications; materials used

3 Understand the principles and practices associated with the provision of simple single-phase electrical systems to buildings

Electrical systems: requirements of systems (sufficient capacity, prevention of excessive current, protection from shock, prevention of fire, means of isolation); components of domestic systems eg main service fuse, meter, main switch, consumer control unit, residual current devices (rcd), miniature circuit breakers (mcb) or fuses, earth connection, outlet sockets, fuses in plugs and/or appliances; principles and layouts of ring main circuits to socket outlets, radial circuits for lighting, radial circuits for high power appliances, electric cookers, showers and water heaters

4 Understand the principles and practices associated with the provision of gas supplies to buildings

Gas supplies: requirements of systems needed for adequate supply of ventilation air to support combustion; effective flue arrangements to dispose of combustion products; supply from gas main into building up to and including the gas meter

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P1 explain the distribution of cold water by direct and indirect systems [IE1, IE2, IE4, CT5, RL4, SM3]	M1 specify hot and cold water systems in terms of materials and appropriate dimensions and/or capacities of fittings and components	D1 evaluate the advantages and disadvantages of the direct and indirect systems used in hot and cold water supplies and suggest situations where each might be appropriate
P2 explain, with the use of clear and accurate diagrams, the provision and distribution of hot water by direct and indirect systems [IE1, IE2, IE4, CT5, RL4, SM3]		
P3 explain the provision of above and below ground drainage systems [IE1, IE2, IE4, CT5, RL4, SM3]	M2 specify above and below ground drainage systems in terms of materials and appropriate falls, dimensions and/or capacities of fittings and components	D2 justify the use of single-stack above ground drainage systems, and separate below ground drainage systems, for foul and surface water in modern houses.
P4 explain the installation of single-phase electrical systems [IE1, IE2, IE4, CT5, RL4, SM3]	M3 distinguish between electrical and gas installations in terms of important health and safety issues.	
P5 explain the installation of gas supply systems. [IE1, IE2, IE4, CT5, RL4, SM3]		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Tutors delivering this unit have opportunities to use a wide range of techniques. Lectures, discussions, seminar presentations, site visits, supervised practicals, research using the internet or library resources and use of personal or industrial experience are all suitable. Delivery should stimulate, motivate, educate and enthuse learners. Visiting expert speakers could add to the relevance of the subject.

The four learning outcomes should be treated separately as they refer to entirely separate building services. It should be noted that the unit content relating to learning outcomes 1, 2 and 3 refers, in the main, to the distribution of each service within the house or, in the case of drainage, inside the house, outside the house and underground. The unit content for learning outcome 4 should just cover how the gas main is connected to the gas meter. Details of internal distribution to individual gas appliances are not required at this stage, but learners must be made aware that a 'competent person' must install gas appliances. Learners should know what is meant by the term 'competent person'.

It is highly unlikely that learners will have the opportunity to practise the practical installation of building services, and these same services will largely be hidden from view in learners' homes. It is, therefore, important that learners have the opportunity to visit building sites and plumbing and electrical installation workshops, in colleges or training centres, to see service installations in full view.

Learners should be encouraged to use their homes as a learning aid. They can follow water pipes around the building, examine above ground drainage systems, find out where all the stop-cocks are situated, check outside for manholes and rodding points, locate the consumer control unit and try to match fuses and circuit breakers to electrical circuits within the building. Learners should have the opportunity to carry out simple laboratory tests to simulate the various forms of siphonage that can compromise water seals or, where this is impractical, the same principles should be demonstrated by the tutor. Small models of domestic hot and cold water systems, drainage systems and low voltage electrical circuits can be constructed and used to simulate what happens in buildings.

There are several interactive websites relating to building services which can be accessed using a decent search engine. However, these change so often that none are specifically recommended, but tutors are advised to search them out on a regular basis. Incomplete diagrams can be issued to learners in hard copy for them to complete as part of a formative assessment. Learners can then complete multiple copies until a functional solution is obtained.

Group activities are permissible, but tutors will need to ensure that individual learners have equal experiential and assessment opportunities.

Health, safety and welfare issues are paramount and should be reinforced through close supervision of all workshops and activity areas, and risk assessments must be undertaken before practical activities are taken. Centres are advised to read the *Delivery approach* section in the specification, and *Annexe H: Provision and Use of Work Equipment Regulations 1998 (PUWER)*.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
<p>Introduction by tutor</p> <p>Cold water – whole-class tutor-led session on cold water systems using audio-visual aids, models and apparatus, as available, to support delivery</p> <p>Tour of centre to see cold water supplies, site visits to house building sites to see newly installed cold water systems, visits to plumbers' merchants and DIY stores to see materials and component parts, visits to college workshops to see work in progress</p> <p>Individual learner research on direct and indirect systems</p>
<p>Hot water – whole-class, tutor-led session on hot water systems using audio-visual aids, models and apparatus, as available, to support delivery</p> <p>Tour of centre to see hot water supplies, site visits to house building sites to see newly installed hot water systems, visits to plumbers' merchants and DIY stores to see materials and component parts, visits to college workshops to see work in progress</p> <p>Individual learner research on direct and indirect systems</p>
Assignment 1: Hot and Cold Water
<p>Above and below ground drainage – whole-class, tutor-led session on drainage systems using audio-visual aids, models and apparatus, as available, to support delivery</p> <p>Tour of centre to see drainage systems, site visits to house building sites to see newly installed drainage systems, visits to plumbers' merchants and DIY stores to see materials and component parts, visits to college workshops to see work in progress</p> <p>Use of learners' own homes to note single-stack systems, inspection chambers and rodding points from outside the house.</p> <p>Individual learner research on single-stack and dual-stack systems</p>
Assignment 2: Above and Below Ground Drainage
<p>Electrical supplies – whole-class, tutor-led session on electrical systems using audio-visual aids, models of power systems and lighting systems, and other apparatus, to support delivery</p> <p>Tour of centre to see power and lighting systems, site visits to house building sites to see newly installed electrical systems, visits to builders' merchants and DIY stores to see materials and component parts, visits to college workshops to see work in progress Use of learners' own homes to note consumer unit, meter and other parts of system</p> <p>Individual learner research on ring mains and radial systems</p>
<p>Gas supplies – whole-class, tutor-led session on gas installations using audio-visual aids and other apparatus to support delivery</p> <p>Tour of centre to see gas boilers, flues, meters and entry points, site visits to house building sites to see newly installed gas services, visits to builders' merchants and DIY stores to see materials and component parts, visits to college workshops to see work in progress</p> <p>Use of learners' own homes to note meter, entry points and flues</p> <p>Individual research on different types of flue</p>
Assignment 3: Electricity and Gas Supplies
<p>Review of unit and assignment feedback</p>

Assessment

Evidence for this unit may be gathered from a variety of sources, including well-planned investigative assignments, case studies or reports of practical assignments.

There are many suitable forms of assessment that could be used and tutors are encouraged to consider and adopt these where appropriate. Some example assessment approaches are suggested below. However, these are not intended to be prescriptive or restrictive, and are provided as an illustration of the alternative forms of assessment evidence that would be acceptable.

The structure of the unit suggests that the grading criteria could be addressed fully by using three assignments. The first of these would cover P1, P2, M1 and D1, the second would cover P3, M2 and D2 and the third P4, P5 and M3.

To achieve a pass grade learners must meet the five pass criteria listed in the grading grid.

For P1, learners must produce clear and accurate diagrams to explain functional direct and indirect cold water distribution systems that comply with relevant legislation. They must produce separate drawings of direct and indirect functional systems. Line diagrams are permitted but conventional symbols must be used for all components.

For P2, learners must produce clear and accurate diagrams to explain functional direct and indirect hot water provision and distribution systems that comply with relevant legislation. They must produce separate drawings of direct and indirect functional systems. Line diagrams are permitted but conventional symbols must be used for all components.

For P3, learners must produce clear and accurate diagrams to explain the provision of above and below ground functional drainage systems that comply with relevant legislation. This should include separate drawings of single-stack and two-pipe functional systems for providing above ground drainage **and** separate drawings of separate and combined functional systems. Line diagrams are permitted but conventional symbols must be used for all components.

For P4, learners must produce clear and accurate diagrams to explain the installation of single-phase electrical systems that comply with relevant legislation. This should include a diagram of a ring main system that includes a consumer control unit with isolating switch, several 13A socket outlets, one 13A spur socket outlet, and live, neutral and earth cables. They should also produce a diagram of a simple lighting system incorporating several one-way switches and a single two-way switch. Line diagrams are permitted but conventional symbols must be used for all components.

For P5, learners must produce clear and accurate diagrams to explain the installation of gas supply systems that comply with relevant legislation. This should include diagrams showing how buildings are connected to gas mains both with the meter inside the house and on the external wall. The systems drawn must be functional. Line diagrams are permitted but conventional symbols must be used for all components.

To achieve a merit grade learners must meet all of the pass grade criteria and the three merit grade criteria.

For M1, learners must specify hot and cold water systems in terms of materials and appropriate dimensions and/or capacities of fittings and components. This will include all relevant dimensions and pipe diameters, and the capacity of any cisterns, hot water cylinders and so on. This could be provided as annotation to the diagrams provided for P1 and P2.

For M2, learners must specify above and below ground drainage systems in terms of materials and appropriate falls, dimensions and/or capacities of fittings and components. This will include all relevant dimensions, pipe diameters, angles and/or curve radii as appropriate. This could be an annotation to the diagrams provided for P3.

For M3, learners must distinguish between electrical and gas installations in terms of important health and safety issues.

In the case of gas supplies, learners must emphasise the need for a constant and adequate supply of ventilation air to ensure complete combustion of natural gas and the need for effective flue arrangements to remove the products of combustion (flue gases). Learners do not need to go into detail about standard and balanced-flue outlets. In the case of electricity supplies, learners must consider the factors (cables of sufficient capacity, prevention of excessive currents, protection from shock, prevention of fire and means of isolation) that must be taken into account and the way in which the components (fuses, mains switch, circuit breakers, earth connection) and wiring systems address these factors. Evidence should be in the form of a report containing text and images, supported by tables, charts, graphs and calculations where relevant.

To achieve a distinction grade learners must meet all of the pass and merit grade criteria **and** the two distinction grade criteria.

For D1, learners must evaluate the advantages and disadvantages of the direct and indirect systems used in the supply of hot and cold water, suggesting situations where each might be appropriate. Examples of suitable approaches to evidence are as for M3.

For D2, learners must justify the use of single-stack above ground drainage systems, and separate below ground drainage systems, for foul and surface water, in modern house building. Examples of suitable approaches to evidence are as for M3 and D1.

Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1, D1	Hot and Cold Water	As a builder you have been asked to explain hot and cold water systems for low-rise domestic and commercial properties of either traditional or modern design, as appropriate.	Annotated diagrams supported by text.
P3, M2, D2	Above and Below Ground Drainage	As a builder you have been asked to explain drainage systems for low-rise domestic and commercial properties of either traditional or modern design, as appropriate.	Annotated diagrams supported by text.
P4, P5, M3	Electricity and Gas Supplies	As a builder you have been asked to explain electrical and gas installations for low-rise domestic and commercial properties of either traditional or modern design, as appropriate.	Annotated diagrams supported by text.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Construction and the Built Environment sector suite. This unit has particular links with the following unit titles in the Construction and the Built Environment suite:

Level 1	Level 2	Level 3
	Exploring Building Services Techniques in Construction	The Underpinning Science for the Provision of Human Comfort in Buildings
	Performing Plumbing Operations	Building Services Science
	Performing Electrical Operations	Low Temperature Hot Water Heating in Building Services Engineering
		Plumbing Technology in Building Services Engineering
		Electrical Installation Standards and Components in Building Services Engineering

The unit builds on the knowledge, understanding and skills contained in the core units together with similar units at Higher National and degree level.

Essential resources

Centres should ideally have access to online technical and manufacturers' literature, or hard copies where this is not possible. The use of readily available visual aids would be advantageous. These can be in the form of sectioned models or part of live installations. Centres that run plumbing, gas fitting and electrical installation training courses would be well advised to make use of these facilities for demonstration purposes. Centres without these facilities should arrange visits to engineering and construction sites and manufacturers' premises instead. Centres should have access to sets of architectural drawings, heating system installations and schematic drawings to support the learning process and to facilitate assessments. It is anticipated that most learners will wish to use ICT to produce their reports and many may wish to use CAD techniques to produce their drawings. Many learners will have access to ICT at home or work, but not all will have access to CAD facilities at work and few will have it at home. Centres should consider how they could meet this need.

Employer engagement and vocational contexts

Support to enable centres to initiate and establish links to industry, and to networks arranging visits to industry and from property practitioners is given below:

- Learning and Skills Network – www.vocationallearning.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- The Royal Institution of Chartered Surveyors – www.rics.org
- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI University of Warwick) – www.warwick.ac.uk/wie/cei/

Indicative reading for learners

Textbooks

- Garrett R H – *Hot and Cold Water Supply* (Blackwell Science (UK), 2000) ISBN 0632049855
- Hall F and Greeno R – *Building Services Handbook* (Butterworth-Heinemann, 2003) ISBN 0750661437
- Harrison H and Trotman P – *Building Services* (IHS BRE, 2000) ISBN 1860814247
- HSE – *Electricity at Work: Safe Working Practices* (HSE Books, 2003) ISBN 0717621642
- Knight J – *Newnes Building Services Pocket Book* (Butterworth-Heinemann, 2003) ISBN 0750657855
- Saxon F – *Tolley's Domestic Gas Installation Practice: 2 (Gas Service Technology)* (LexisNexis UK, 2001) ISBN 075451434X
- Scaddon B – *Electrical Installation Work* (Butterworth-Heinemann, 2002) ISBN 0750656417
- Stokes G – *Handbook of Electrical Installation Practice* (Blackwell Science (UK), 2003) ISBN 0632060026
- Young L and Mays G – *Water Regulations Guide* (WRC Publications, 2000) ISBN 0953970809

Journals

- Building Services Engineering Research and Technology Journal* – Sage Publications Ltd
- Building Services and Environmental Engineering* – Datateam Publishing Ltd
- Building Sustainable Design* – UMP
- Modern Building Services* – Portico Publishing Ltd

Websites

- www.buildingdesign.co.uk Building design
- www.cibse.org The Chartered Institution of Building Services Engineers

Delivery of personal, learning and thinking skills (PLTS)

The following table below identifies the personal, learning and thinking skills (PLTS) opportunities that have been included within the assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	<p>identifying questions to answer and problems to resolve, planning and carrying out research, appreciating the consequences of decisions, analysing and evaluating information, judging its relevance, as they:</p> <ul style="list-style-type: none"> ● explain, with the use of clear and accurate diagrams, the distribution of cold water by direct and indirect systems ● explain, with the use of clear and accurate diagrams, the provision and distribution of hot water by direct and indirect systems ● explain, with the use of clear and accurate diagrams, the provision of above and below ground drainage systems ● explain, with the use of clear and accurate diagrams, the installation of single-phase electrical systems ● explain, with the use of clear and accurate diagrams, the installation of gas supply systems
Creative thinkers	<p>trying out alternatives or new solutions and following ideas through, as they:</p> <ul style="list-style-type: none"> ● explain, with the use of clear and accurate diagrams, the distribution of cold water by direct and indirect systems ● explain, with the use of clear and accurate diagrams, the provision and distribution of hot water by direct and indirect systems ● explain, with the use of clear and accurate diagrams, the provision of above and below ground drainage systems ● explain, with the use of clear and accurate diagrams, the installation of single-phase electrical systems ● explain, with the use of clear and accurate diagrams, the installation of gas supply systems
Reflective learners	<p>inviting feedback and dealing positively with praise, setbacks and criticism, as they:</p> <ul style="list-style-type: none"> ● explain, with the use of clear and accurate diagrams, the distribution of cold water by direct and indirect systems ● explain, with the use of clear and accurate diagrams, the provision and distribution of hot water by direct and indirect systems ● explain, with the use of clear and accurate diagrams, the provision of above and below ground drainage systems ● explain, with the use of clear and accurate diagrams, the installation of single-phase electrical systems ● explain, with the use of clear and accurate diagrams, the installation of gas supply systems

Skill	When learners are ...
Self-managers	<p>organising time and resources and prioritising actions, as they:</p> <ul style="list-style-type: none"> • explain, with the use of clear and accurate diagrams, the distribution of cold water by direct and indirect systems • explain, with the use of clear and accurate diagrams, the provision and distribution of hot water by direct and indirect systems • explain, with the use of clear and accurate diagrams, the provision of above and below ground drainage systems • explain, with the use of clear and accurate diagrams, the installation of single-phase electrical systems • explain, with the use of clear and accurate diagrams, the installation of gas supply systems.

● Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using a wide range of ICT applications, and especially the internet, to research water, drainage, electrical and gas services
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	using a wide range of ICT applications, and especially the internet, to research water, drainage, electrical and gas services
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records 	producing reports and drawings for hot and cold water systems
Bring together information to suit content and purpose	
Present information in ways that are fit for purpose and audience	
Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists	communicating with other learners and the tutor by email and sending, opening and saving attachments for water, drainage, electrical and gas services
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	
Identify the situation or problem and the mathematical methods needed to tackle it	
Select and apply a range of skills to find solutions	
Use appropriate checking procedures and evaluate their effectiveness at each stage	
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	
Draw conclusions and provide mathematical justifications	

Skill	When learners are ...
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing research findings for water, drainage, electrical and gas services, and communicating findings to other learners and the tutor using a variety of techniques
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching water, drainage, electrical and gas services from books, journals, CD ROMs and websites
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	presenting the results of their research into water, drainage, electrical and gas services in report format using clear and accurate English.