Unit 34: Heating in Building Services Engineering

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

Modern heating systems are expected to do much more than maintain the temperature of a space. They must be efficient, functional, environmentally friendly and should contribute to sustainable development. They might also be expected to add to the appearance and ambience of the buildings in which they are installed.

A sound understanding of the principles and practices of modern low pressure hot water (lphw) heating is therefore fundamental to the role of the building services engineer. This is particularly true for those involved in the heating, ventilating and air conditioning (HVAC) sector, also known as the 'mechanical building engineering services'.

This unit explores the development of lphw heating installations in a progressive manner. This begins with agreement of the client's requirements for a system, continues through the design of layouts and the sizing, selection and specification of pipes and equipment, and concludes with the commissioning of a system and its subsequent maintenance.

The unit does not consider specialised heating systems such as high pressure hot water and steam, such as are usually associated with large-scale projects. These systems and other more specialised heating installations are dealt with in the Higher National programmes in Building Services Engineering.

Learning outcomes

On completion of this unit a learner should:

1 Know how to establish heating requirements for buildings, select design conditions and establish heating loads

2 Know the operational features and characteristics of low pressure hot water (lphw) heating equipment, plant and materials and how they are applied in use

3 Be able to design low pressure hot water (lphw) heating installations for specific applications

4 Understand how to size, select and specify heating installation pipework, plant and equipment.

Unit content

1 **Know how to establish heating requirements for buildings, select design conditions and establish heating loads**

Heating requirements: reasons for heating buildings or zones for domestic, commercial, industrial and public sector applications; client, user and environmental requirements and considerations; locations with special heating requirements

Design conditions: factors used to select internal design temperatures; external design temperatures; infiltration rates for winter heating applications; thermal indices; use of regulations, codes of practice, standards and guidance notes when selecting design conditions for winter heating; exercising judgement when selecting design temperatures for non-standard locations; environmental implications of design decisions

Heating loads: calculation of heat losses using manual calculations and software; use and validity of 'rules-of-thumb'; legislative constraints; energy standards; environmental implications of heating energy requirements; methods of reducing energy requirement

2 **Know the operational features and characteristics of low pressure hot water (lphw) heating equipment, plant and materials and how they are applied in use**

Heat emitters for lphw heating: characteristics; appearance; operational features; installation and application of heat emitters, eg panel, sectional, low surface temperature and architectural feature radiators, natural convectors, fan convectors, unit heaters, radiant panels, underfloor heating, variations of these and hybrid emitters; methods of heat emission; control of output from heat emitters; criteria for selection

Boiler plant and heat generators: characteristics; operational features; firing; flue arrangements; application of principal types of lphw boilers and other heat generators; installation requirements; regulations, standards and environmental implications; techniques for maximising energy efficiency/economy; boiler mountings; criteria for selection

Heating pumps: component parts; characteristics and operational features of single and twin head pumps for lphw heating; direct and indirect drives; glands and seals; pipeline connection arrangements; methods of altering rotation speed and the effect on pump duty; criteria for selection

Pipework and jointing systems: pipework materials used for lphw heating installations; standard pipework sizes; characteristics and features of jointing; assembly and installation procedures; relationship between physical properties of pipework materials and their application; comparative costs and benefits of various pipework materials; criteria for selection

Expansion accommodation devices: characteristics of methods and devices used to accommodate linear and angular movement due to pipework expansion in lphw heating installations, eg natural pipe flexibility, loops, bellows, sliding joints, flexible connections; requirement for anchors, guides and supports; criteria for selection

Heating installation ancillary components: characteristics and operational features of lphw heating installation items such as air removal devices; valves, eg isolation, drain, float operated; simple flexible diaphragm expansion vessels; regulating (commissioning) valves; flow measurement devices; test points; criteria for selection

3 **Be able to design low pressure hot water (lphw) heating installations for specific applications**

Design of lphw heating installations: location of heat emitters; pipework systems and arrangements for low pressure hot water (lphw) heating installations eg one pipe, two pipe and reverse return; features of good pipework circuit design; criteria and methods for zoning installations; use and arrangement for constant and variable temperature circuits; inter-relationship of cold feed, vent pipe and pumps; pipework accommodation and routing; arrangements for initial fill, top up and accommodation of expansion water; location of pipework expansion devices and their installation requirements; prevention of noise problems

Design of lphw boiler and heat generation plant: space requirements for single and multiple boiler configurations; structural and building work requirements to accommodate lphw heat generation plant; connection of circuits to heat generation plant eg pipework headers, primary circuits

Provision for commissioning and maintenance: reasons for commissioning lphw heating pipe networks; types and location of flow regulation and metering devices; provision of means of isolation, air removal and draining; location of filters and dirt removal devices; prevention of corrosion; methods and equipment used for chemical treatment of installations

Graphical detailing: production of appropriate drawings and sketches as required to communicate heating system detailed designs; use of drawing symbols and annotation

4 **Understand how to size, select and specify heating installation pipework, plant and equipment**

Pipework circuits: selection of pipework design parameters; use of manual calculations and computer software for calculation of mass flow rates; selection of pipe sizes; calculation of pipework emission and temperature distribution in one and two-pipe circuits; total resistance of index circuits; methods of producing balanced systems and absorbing excess pressure at branches; establishing commissioning data for pipework distribution networks

Pumps: application of pump margins; determining pump duty; selection of pumps from manufacturers' data; pump and system characteristics; efficiency and operational features; cause, effect and prevention of cavitation; production of pump schedules; establishing commissioning data

Heat emitters: selection of heat emitters from manufacturers' data; variation of emitter output with operational and installation characteristics; hydraulic resistance; production of heat emitter specifications and schedules

Boilers/heat generators: selection of boiler from manufacturers' data; hydraulic resistance and maintaining minimum flow rates; combustion ventilation and fuel/energy requirements; production of boiler specifications and schedules

Expansion devices and other heating installation components: selection of components from manufacturers' data; production of specifications and schedules

Grading grid

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

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 identify the need for heating and select appropriate internal and external design conditions for specific applications	M1 evaluate heating loads of buildings for compliance with energy conservation requirements and recommend effective methods of achieving energy reductions	D1 analyse and justify the design rationale used in the production of a heating design and demonstrate how the proposed design meets the needs of the client and their building
P2 determine heating loads for buildings	M2 compare alternative items of lphw heating plant and make valid and appropriate recommendations as to the most suitable for specific heating applications	D2 analyse and justify the design parameters and rationale used in the sizing and specification of heating pipe networks, plant and components and demonstrate how the proposed selections satisfy the appropriate performance requirements.
P3 describe how the features and characteristics of lphw heat emitters, pumps, boiler plant, pipework and ancillary equipment contribute to their selection for specific applications	M3 produce comprehensive designs for lphw heating installations, plant arrangements and control strategies	

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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:**
P4 produce basic functional and workable designs for lphw heating installations appropriate to specific buildings for a variety of heat emitters and circuits P5 determine pipework sizes, flow rates, temperature distributions and resistances for lphw heating circuits using recognised procedures P6 size and select appropriate models of lphw heat emitters, pumps, boilers and other ancillary equipment for given heating installations.	M4 produce clear and accurate answers to calculations needed to size lphw heating pipe networks and determine detailed commissioning data M5 analyse installation drawings, design calculations and manufacturers' data to produce detailed specifications, schedules and commissioning data for heat emitters, pumps, boilers and other ancillary components.	

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 and/or library resources and the use of personal and/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 learning outcomes are strongly linked and form a logical and progressive structure. Teaching and learning strategies should reinforce this integrated, learner-centred approach. Learners should appreciate that each aspect and topic forms a progressive, step-by-step, individual stage in the overall process of designing and specifying heating installations.

The method of delivery should, as far as possible, be activity based. Learning activities could include the use of case studies, site visits, product investigations and design exercises. The unit should not be perceived as an academic exercise and should at all times be based on real-life applications, and reflect industry best practice. Delivery should provide a balance between the calculations implicit in learning outcomes 1 and 4, the knowledge and understanding required by learning outcomes 1 and 2 and the creativity and application required by learning outcome 3.

Reference should be made to appropriate regulations, standard building services guides and sources of reference wherever necessary. Learners should be encouraged to use these documents to make informed decisions relating to the design of lphw heating installations and help them understand the consequences of their decisions.

The use of current manufacturers' product information is also encouraged to help learners apply principles and procedures to real-life situations. This does not mean that the mechanistic use of manufacturer's data, with little consequent need for understanding, is always acceptable. The same logic applies to the use of specialist building services engineering design software and spreadsheets. Their use is of course, encouraged, but only after an understanding of the underlying principles required for manual calculations have been established.

The focus of this unit is on linking principles with practical applications and this, in turn, implies that learners will have a basic understanding of science and analytical methods before starting this unit. Even if learners do not possess this knowledge and understanding on entry, there will be no delivery and/or assessment issues if the relevant core units are delivered early in the programme.

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

Health, safety and welfare issues are paramount and should be strictly reinforced through close supervision of all workshops and activity areas, and risk assessments must be undertaken prior to practical activities. Centres are advised to read the *Delivery approach* section on page 24, and *Annexe G: Provision and Use of Work Equipment Regulations 1998 (PUWER)*.

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 employed, and tutors are encouraged to consider and adopt these where appropriate. Some examples of possible 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. General guidance on the design of suitable assignments is available on page 19 of this specification.

Some criteria can be assessed directly by the tutor during practical activities. If this approach is used then suitable evidence would be observation records or witness statements. Guidance on the use of these is provided on the Edexcel website.

The unit has been written to allow all the assessment evidence for all the learning outcomes to be produced from a single, well-designed project based on the design of lphw heating installations for real buildings.

The building(s) selected for the purpose of assessment should have a wide variety of uses, functions, activities and features. This will give learners the opportunity to consider options and make decisions. For example, buildings such as office buildings with large numbers of similar rooms would not be appropriate as they provide insufficient opportunity for variety or decision-making. It is equally important that any buildings selected are not too complex and that lphw heating installations are a realistic solution. Domestic, low rise commercial and small industrial buildings would be appropriate.

Learners should be given a range of architectural drawings necessary for them to extract the required information. These could be some or all of plans, elevations, sections and/or details.

Where centres intend to use buildings of their own design, the buildings must meet current building design standards and should contain the same information as would be present in professionally produced architectural drawings. Although this unit can stand-alone it is strongly recommended that, where learners are concurrently studying other units, the assessment evidence is co-ordinated to avoid duplication.

In such cases centres may want to consider integrative assignments. For example, assessments associated with thermal comfort, heat loss calculations, properties of materials, sustainable development, environmental impact, flow of fluids, performance of pumps, control applications, can be integrated within the single assessment instrument designed to meet the grading criteria for this unit.

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

For P1, learners must identify the need for heating and select appropriate internal and external design conditions for specific applications. For those areas requiring heating, learners should select internal design temperatures, infiltration rates and external design temperatures. In each case, they must support their selections by indicating all the sources of reference used and all the factors used in their selection. Assessment for P1 must extend beyond the mechanistic use of standard

tables. The buildings specified for the assessment must contain locations where a degree of judgement is required of learners. Evidence could be in the form of a presentation or a report supported by appropriate data, graphs and tables.

For P2, learners must determine heating loads for buildings. They should identify the thermal properties of the materials used in a building and calculate the heat losses using standard procedures. Industry standard software may be used for determining the heat loss but this should be used to support and check manual calculations, not to replace them. Examples of suitable evidencing approaches could be as for P1, but also supported by appropriate calculations.

For P3, learners must describe how the features and characteristics of lphw heat emitters, pumps, boiler plant, pipework and ancillary equipment contribute to their selection for specific applications. Examples of suitable evidencing approaches could be as for P1.

For P4, learners must produce basic functional and workable designs for lphw heating installations appropriate to specific buildings for a variety of heat emitters and circuits. Designs should include all necessary major items of plant and must show that factors such as the type of circuit, pipework routing, accommodation and appearance have all been considered.

For P5, learners must determine pipework sizes, flow rates, temperature distributions and resistances for lphw heating circuits using recognised procedures. The size of the circuit should be representative of the circuit(s) used for P4. There should be evidence that learners understand the procedures used. Evidence could be in the form of a report supported by calculations and diagrams as appropriate.

For P6, learners must size and select appropriate models of lphw heat emitters, pumps, boilers and other ancillary equipment for given heating installations. There should be evidence that learners understand the procedures used. The evidence could be in the form of a report supported by calculations and diagrams as appropriate.

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

For M1, learners are required to evaluate heating loads of buildings for compliance with energy conservation requirements and recommend effective methods of achieving energy reductions. Learners should indicate whether given buildings comply with the current legislation aimed at limiting heat losses (eg building regulations) and whether they comply with any appropriate energy assessment procedure or energy targets. They are not expected to evaluate compliance with every stage or aspect of the legislation or assessment procedure, but they must give evidence that they have evaluated those aspects that relate to elemental heat losses from the building. This could be a natural extension of the work carried out for P2.

For M2, learners must compare alternative items of lphw heating plant and make valid and appropriate recommendations as to the most suitable for specific heating applications. Learners should relate their decisions to the needs of particular clients and buildings and must outline any constraints and environmental considerations. This is a natural extension of the work carried out for P1 and P3.

For M3, learners must produce comprehensive designs for lphw heating installations, plant arrangements and control strategies. The designs should include details of all items of plant and equipment, including controls, and their locations. There should be clear evidence that learners have carefully considered all aspects of the proposed design, including the main features and constraints of the building, the client's requirements and the need for maintenance and commissioning. Drawings should include both layout and schematic drawings. All drawings and reports must be well produced, detailed and unambiguous. This is a natural qualitative extension of the work carried out for P4.

For M4, learners must produce clear and accurate answers to calculations needed to size lphw heating pipe networks and determine detailed commissioning data. This should include the heat loads of each section, the effect for pipework emissions, proportional flow rates for each section, pipe sizes, flow, return and mean water temperatures at various locations, index circuit resistance. It should also include procedures for absorbing excess pressure at branches to achieve balanced circuits. Learners are expected to extract the necessary commissioning data from these calculations. This could be a natural extension of the work carried out for P5.

For M5, learners must analyse installation drawings, design calculations and manufacturers' data to produce detailed specifications, schedules and commissioning data for heat emitters, pumps, boilers and other ancillary components. Learners are expected to use this data and manufacturers' information to write specifications and select and produce schedules and commissioning information for appropriate makes and models of pumps, heat emitters, boilers and other ancillary equipment. This could be a natural extension of work carried out for P5.

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

D1 requires learners to analyse and justify the design rationale used in the production of a heating design and demonstrate how the proposed design meets the needs of the client and their building. Learners must clearly show how a proposed design meets the needs of the building, the client and end users, as well as the wider issues of environmental impact. As part of the justification learners must link the features of the design with the appropriate underpinning principles. This could be a natural extension of the work carried out for P1, P2, P3, P4, M1, M2 and M3.

For D2, learners must analyse and justify the design parameters and rationale used in the sizing and specification of heating pipe networks, plant and components and demonstrate how the proposed selections satisfy the appropriate performance requirements. In justifying the design parameters learners must clearly explain why they used particular parameters, what alternative parameters could be used and what the effect of using other parameters would be. For plant and components, learners' justification should establish appropriate performance standards (where applicable) and show whether the items of plant and equipment selected meet these standards. As part of the justification, learners are expected to make the link with the appropriate underpinning principles. This could be a natural extension of the work carried out for P5, P6, M4 and M5.

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

The learning outcomes in this unit are closely linked with, for example, *Unit 2: Construction and the Environment, Unit 4: Science and Materials in Construction and the Built Environment, Unit 8: Graphical Detailing in Construction and the Built Environment, Unit 32: Building Services Control Systems, Unit 33: Building Services Science* and *Unit 36: Fluids Static and Dynamic in Building Services Engineering*, together with similar units at Higher National and degree level.

This unit may have links to the Edexcel Level 3 Technical and Professional NVQs for Construction and the Built Environment. Updated information on this, and a summary mapping of the unit to the CIC Occupational Standards, is available from Edexcel. See *Annexe D: National Occupational Standards/mapping with NVQs*.

The content of this unit also covers the knowledge, understanding and skills associated with SummitSkills National Occupational Standards, in particular Unit 015: Design heating and ventilating systems.

There are also links with Summit Skills N-SVQ Level 3: Building Services Engineering Technology and Project Management, in particular Unit SST/NOS 3: Apply Design Principles to Building Services Engineering Projects and Unit SST/NOS 7: Provide Technical and Functional Information to Relevant People.

Summit Skills N-SVQ Level 4: Building Services Engineering Technology and Project Management, in particular Unit SSTE/NOS 7: Prepare and Advise on Building Services Engineering Project Design Recommendations and Unit SSTE/NOS 8: Prepare and Agree Detailed Building Services Engineering Project Designs.

This unit presents opportunities to demonstrate key skills in application of number, communication and problem solving. Opportunities for satisfying requirements for Wider Curriculum Mapping are summarised in *Annexe F: Wider curriculum mapping*.

Essential resources

Centres should have access to a wide range of hard copy or online technical and manufacturers' literature. Some of these are listed below.

The use of readily available visual aids (such as the range of heating plant and components indicated in learning outcome 2) would be highly advantageous. These can be in the form of either sectioned models and/or as part of live installations.

Centres should have access to sets of architectural drawings, heating system installations and schematic drawings to support the learning process and to facilitate assessments. Where these drawings are used as part of the assessment process, it is recommended that repeated use of the same building is avoided to maintain the freshness of the assessment process.

Learners should begin to use the industry-recognised software capable of performing complete thermal analyses of buildings and sizing, selecting and specifying pipework, plant and equipment. It is however vital that, if such software is used, learners are assessed as being able to complete the calculations required in learning outcome 1 and 4 using recognised manual procedures. The same principle applies to the graphical detailing required for learning outcome 3.

Indicative reading for learners

Textbooks

Chadderton D — *Building Services Engineering, 5th Edition* (Taylor & Francis, 2007) ISBN 0415413559

Chartered Institute of Building Services Engineer — *Environmental Design, 7th Edition* (CIBSE, 2006) ISBN 1903287669

Chartered Institute of Building Services Engineer — *Energy Efficiency in Buildings* (CIBSE, 2004) ISBN 1903287340

Chartered Institute of Building Services Engineer — *Heating, Ventilation, Air Conditioning and Refrigeration* (CIBSE, 2005) ISBN 1903287588

Day A, Ratcliffe M and Shepherd K — *Heating Systems, Plant and Control* (Blackwell Science, 2003) ISBN 0632059370

Martin P, Oughton D and Hodkinson S — *Faber and Kell's Heating and Air-conditioning of Buildings, 9th Edition* (Architectural Press, 2001) ISBN 075064642X

Mitchell S and Race G — *A Practical Guide to HVAC Building Services Calculations* (BSRIA, 2003) ISBN 0860226182

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Tutors should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Application of number Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• planning and obtaining data, extracting dimensions and areas from drawings etc for heat loss calculations and pipe sizing exercises • selecting appropriate formulae to solve problems in heating loads, fluid mechanics, flow measurement, plant duties etc • interpreting results from heat loss calculations and using results pipework design calculations to select plant and equipment.	N3.1 Plan an activity and get relevant information from relevant sources. N3.2 Use your information to carry out multi-stage calculations to do with: a amounts or sizes b scales or proportion d using formulae. N3.3 Interpret the results of your calculations, present your findings and justify your methods.

Communication Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• identifying and describing the factors that influence human comfort in the internal environment and selecting design conditions • describing how the features and characteristics of lphw heat emitters, pumps, boiler plant, pipework and ancillary equipment contribute to their selection for specific applications • making comparisons between alternative items of lphw heating plant and making valid and appropriate recommendations for the most suitable for specific heating applications • analysing manufacturers' data to produce detailed specifications, schedules and commissioning data for heat emitters, pumps, boilers and other ancillary components.	C3.2 Read and synthesise information from at least **two** documents about the same subject. Each document must be a minimum of 1000 words long. C3.3 Write **two** different types of documents each one giving different information about complex subjects. One document must be at least 1000 words long.

Problem solving Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• producing basic functional and workable designs for lphw heating installations appropriate for specific buildings requiring a variety of heat emitters and circuits • sizing and selecting appropriate models of lphw heat emitters, pumps, boilers and other ancillary equipment for given heating installations • evaluating heating loads for building compliance with energy conservation requirements and recommending effective methods of achieving energy reductions • making comparisons between alternative items of lphw heating plant and making valid and appropriate recommendations for the most suitable for specific heating applications • analysing and justifying the design rationale used in the production of a heating design and demonstrating how the proposed design meets the needs of the client and their building.	PS3.1 Identify a problem and identify different ways of tackling it. PS3.2 Plan and implement at least one way of solving the problem. PS3.3 Check if the problem has been solved and review your approach to problem solving.