# Unit 34: Low Temperature Hot Water Heating in Building Services Engineering

**Unit code:** M/600/0380

**QCF Level 3:** BTEC Nationals

**Credit value:** 10

**Guided learning hours:** 60

## Aim and purpose

The aim of this unit is to give learners skills and understanding of low temperature hot water heating required for designing and specifying efficient installations for buildings.

## Unit introduction

Heating installations are an essential feature of most buildings in the UK and of many other countries around the world. Modern heating systems are expected to do much more than maintain the temperature of a space. They must be efficient, functional and environmentally friendly, and should contribute to sustainable development. Space heating is a major consumer of energy and therefore a significant source of carbon dioxide ($CO_2$) emissions. As a result of the current drive to reduce $CO_2$ emissions, well-designed heating systems must contribute significantly to achieving these reductions. In addition to being efficient and functional, heating installations are usually expected to be sympathetic to the appearance and ambience of the buildings they are installed in.

A sound understanding of the principles and practices of modern low temperature hot water (LTHW) heating is 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 LTHW heating installations in a progressive manner. This begins with the agreement of client needs and design requirements for a system, continues through the design of layouts, proceeds to the sizing, selection and specification of pipes and equipment, and concludes with the commissioning of a system and its subsequent maintenance.

## Learning outcomes

**On completion of this unit a learner should:**

1 Be able to establish heating requirements for buildings

2 Understand the operational characteristics of low temperature hot water heating equipment and plant

3 Be able to design low temperature hot water heating installations

4 Be able to size, select and specify heating installation pipework, plant and equipment.

# Unit content

## 1 Be able to establish heating requirements for buildings

*Heating requirements*: reasons for heating buildings or zones for domestic, commercial, industrial and public sector applications; client, user and environmental requirements and considerations; effect of building occupation times and patterns; identifying likelihood of future changes; quality/life expectancy of the installation; planning restrictions; locations with special heating requirements

*Design conditions*: factors used to select internal design temperatures; 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: selection of external design temperatures for winter heating; inclusion of geographical location, thermal response and risk of exceedance: infiltration rates for winter heating applications

*Heat losses*: identification and selection of U values for building fabric; calculation of simple heat losses; use and validity of 'rules-of-thumb'; legislative constraints; energy standards; environmental implications of heating energy requirements; methods of reducing energy requirement

## 2 Understand the operational characteristics of low temperature hot water heating equipment and plant

*LTHW plant and equipment*: heat emitters; pipework and jointing systems; heating pumps; boiler plant and heat generators; expansion accommodation devices; ancillary components

*Heat emitters:* eg panel, sectional, low temperature, natural and fan convectors, unit heaters, radiant panels, underfloor heating; characteristics, appearance, operation, installation and application of heat emitters; heat emissions; control of output; selection criteria

*Pipework and jointing systems*: pipework sizes; jointing characteristics; assembly; installation; criteria for selecting materials eg properties, application, costs versus benefits

*Heating pumps*: single and twin head pumps; direct and indirect drives; glands and seals; connection to pipelines; methods to alter rotation speed; effect on pump duty

*Boiler plant and heat generators*: types; characteristics; operational features; applications; boiler mountings; installation; firing; flue arrangements; fuel storage requirements; regulations; standards; environmental issues; maximising energy efficiency

*Expansion accommodation devices*: characteristics; natural pipe flexibility; loops; bellows; sliding joints; flexible connections; anchors; guides; supports

*Ancillary components*: characteristics and features of eg air removal devices; valves (isolation, drain, float operated); flexible diaphragm expansion vessels; regulating valves; flow measurement devices; test points

## 3 Be able to design low temperature hot water heating installations

*Design of LTHW heating installations*: arrangement of components; design of boilers and heat generation plant; commissioning and maintenance; drawings

*Arrangement of components*: location of heat emitters and pipework systems; one pipe, two pipe and reverse return systems; good pipework circuit design; criteria and methods for zoning installations; use and arrangement for constant and variable temperature circuits; 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; prevention of noise problems

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

*Commissioning and maintenance*: reasons for commissioning 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

*Drawings*: communication of detailed designs; use of drawing symbols and annotation; production of appropriate drawings and sketches

## 4 Be able 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

*Plant and equipment*: pumps; heat emitters; boilers and heat generators; expansion devices and other components

*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; commissioning data

*Heat emitters*: selection; variation of emitter output with mean water temperature; hydraulic resistance; production of heat emitter specifications and schedules

*Boilers and heat generators*: selection; hydraulic resistance; maintaining minimum flow rates; combustion, ventilation, fuel/energy requirements; boiler specifications and schedules

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

## 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** | produce pre-design appraisals of the heating requirements of buildings [IE1, IE2, IE3, IE4, IE6, CT1, RL1, TW1, SM1, EP1] | **M1** | recommend methods to achieve energy reductions in specified systems | | |
| **P2** | establish heating system design data and parameters for buildings [IE1, IE2, IE3, IE4, IE6, CT1, RL1, TW1, SM1, EP1] | | | | |
| **P3** | establish the thermal performance properties of building fabric and infiltration rates [IE1, IE2, IE3, IE4, IE6, CT1, RL1, TW1, SM1, EP1] | | | | |
| **P4** | perform calculations to determine building total heat loss [IE1, IE3, IE4, CT1, CT2, CT3, CT4, CT5] | | | | |
| **P5** | describe the operational characteristics of plant and equipment associated with LTHW heating systems [IE1, IE2, IE3, IE4, IE6, CT1, RL1, TW1, SM1, EP1] | **M2** | compare different types of LTHW heat emitters in terms of performance-in-use | | |
| **P6** | explain how the operational characteristics of LTHW plant and equipment influence their application [IE1, IE2, IE3, IE4, IE6, CT1, RL1, TW1, SM1, EP1] | | | | |

| 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:** |
| **P7** plan heating installation pipework configuration and design layouts [IE1, IE2, IE4, IE6, CT1, CT2, CT4, RL3, RL6, SM3] | **M3** evaluate designs for given LTHW heating systems | **D1** justify the rationale used in the production of a heating design |
| **P8** plan simple boiler/heat generation plant arrangements and configurations [IE1, IE2, IE4, IE6, CT1, CT2, CT4, RL3, RL6, SM3] | | |
| **P9** produce appropriate design drawings of proposed LTHW installations [IE1, IE2, IE4, IE6, CT1, CT2, CT4, RL3, RL6, SM3] | | |
| **P10** select design parameters and calculate consequent mass flow rates, pipe sizes and circuit resistances for LTHW distribution networks [IE1, IE2, IE4, IE6, CT1, CT2, CT4, RL3, RL6, SM3] | **M4** produce detailed schedules and commissioning data for LTHW systems. | **D2** justify the principles used in the sizing and specification of heating systems. |
| **P11** perform the calculations required to select circulation pumps for LTHW heating circuits [IE1, IE2, IE4, IE6, CT1, CT2, CT4, RL3, RL6, SM3] | | |
| **P12** specify boilers and other heat generation plant in terms of efficiency and sustainability. [IE1, IE2, IE4, IE6, CT1, CT2, CT4, RL3, RL6, SM3] | | |

**PLTS**: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated 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, manufacturer's demonstrations, research (using the internet and/or other online resources) and use of personal and/or industrial experience are all suitable. Delivery should stimulate, motivate, educate and enthuse learners. Visiting expert speakers and manufacturers could add to the relevance of the subject.

The learning outcomes are closely 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 form 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 balance 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 LTHW heating installations and help them understand the consequences of their decisions. Energy efficiency, sustainable construction and the environmental implications of heating system design and specification are not identified as separate topics but they must form an inclusive theme in the delivery of all parts of this unit.

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 manufacturers' data, with little understanding, is acceptable. The same logic applies to the use of specialist building services engineering design software and spreadsheets. Their use is encouraged, but only after an understanding of the underlying principles required for manual calculations has been established.

The focus of this unit is on the application of principles and procedures to make decisions and produce solutions to realistic heating scenarios. This implies that before starting this unit learners should have an understanding of the science of thermal comfort, heat transfer, thermal properties of materials, pressure in fluids, fluid flow and the mathematics associated with the manipulation of these properties. Even if learners do not have this knowledge and understanding on entry, there will be no delivery and/or assessment issues if these relevant core principles are delivered early in the programme or concurrently with this unit. Delivery of the various scientific topics needs to be coordinated with those in this unit. There is considerable scope however for the integration of the teaching and assessment of scientific principles with the application of those principles via this unit.

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 |
|---|
| Whole-class teaching – introduction to unit content and grading criteria, importance of good design in heating systems and the consequences of poor design, fundamental components of heating systems, understanding and interpreting buildings and their functioning, client briefs and end users needs, reasons for heating buildings |
| Learner exercises – study and assimilate architectural drawings, gathering site and design information and identifying client heating needs |
| Whole-class teaching – selection of internal winter design temperatures, relationship between thermal comfort factors and temperatures selected for locations |
| Learner exercises – selecting internal design temperatures for locations |
| Whole-class teaching – selection of external winter design temperatures for geographical locations and thermal response, acceptable risk of exceedance of conditions for applications, identification of building fabric information, obtaining U values for fabric and glazing from reference sources and calculation |
| Learner practice exercises – use source data to obtain U values for solid ground floors, windows and skylights, standard walls etc, calculating U values for other structures |
| Whole-class teaching – estimating infiltration rates for buildings for winter heating, sources and use of empirical data for estimating infiltration rates for winter heating applications, procedures for the calculation of heat loss from rooms, interpreting and making sense of heat loss results, methods of checking accuracy, heat loss estimating techniques, advantages and disadvantages of using proformas, spreadsheet or commercial software for heat loss calculations |
| Learner practice – calculation of steady state space heat losses for locations and buildings |
| Whole-class teaching – preparation and planning for Assignment 1<br><br>Overview, status and application of legislative constraints and energy standards for thermal performance of buildings, effectiveness of strategies for reducing heat losses, designing for energy efficiency |
| **Assignment 1: Client Needs, Design Data and Heat Losses** |
| Whole-class teaching – overview of heating systems and their plant and equipment, centralised and decentralised systems |
| Learner-guided research activities – various types of heat emitters used for LTHW installations, their features, characteristics, operation, advantages and disadvantages |
| Whole-class teaching – selection criteria for heat emitters, location of heat emitters to achieve uniform room temperature, control of heat emission from heat emitters |
| Whole-class teaching and case studies – pipework configurations for LTHW heating systems, features and characteristics of one, two and two-pipe reverse return pipework arrangements, accommodating and routing pipework within buildings, criteria for good pipework design, reasons for and methods of zoning installations, standards and conventions for installation drawings for heating systems |
| Learner-guided research and case study activities – pipework materials and jointing systems associated with LTHW installations, standard sizes, comparative features, criteria for selection |
| Whole-class teaching – feed, expansion and initial fill arrangements, comparison between open vented and sealed expansion vessel arrangements<br><br>Valves, drains, air vents; need for, location of, commissioning devices and test points |
| Whole-class teaching – operational features, construction and component parts of circulating pumps for LTHW heating systems, pressure distribution in heating systems, effect of positioning the pump in heating systems with respect to feed-pipe (or expansion vessel) and vent pipe locations |

| Topic and suggested assignments/activities and/assessment |
|---|
| **Assignment 2: Operational Characteristics of LTHW Systems** |
| Individual formative exercises – selection and positioning of heat emitters, design of heating systems and pipework layouts, production of annotated layout drawings |
| Whole-class teaching – quantifying linear expansion in pipework, devices and methods of accommodating expansion in pipework installations, requirements for pipework expansion devices, identifying locations where such devices are needed |
| Learner exercises – quantify expansion, recommend expansion control methods |
| Learner-guided research activities – construction and features of the various types of boilers and heat generators used for LTHW systems, fuels used for boilers and their supply arrangements |
| Pipework configurations for single and multiple boilers, boiler mountings, flue arrangements for single and multiple boilers, planning boiler layouts, space requirements and builder work for boilers associated with boiler plant design, requirement to provide ventilation supply for combustion air |
| Learner exercises – producing annotated layout and schematic drawings for boiler plant and heating systems |
| Whole-class teaching – mechanisms for reducing environmental impact of boiler emissions eg condensing and biomass boilers, overview of the use of small-scale combined heat and power plant and heat pumps as heating sources |
| **Assignment 3: Heating Equipment, Feasible Options and Layout Designs** |
| Whole-class teaching – selection of flow and return temperatures and desirable velocities for LTHW pipework circuits, effect of using alternative temperatures, determining approximate heat loads for circuits and calculation of provisional mass flow rates, selection of preliminary pipe sizes for calculated flow rates, calculation routines and procedures, use of spreadsheets and calculation proformas |
| Individual formative exercises – pipe network calculations for preliminary flow rates and pipe sizing for heating circuits |
| Whole-class teaching – calculating pipework emissions and total heat loads for circuits, mass flow and temperature distribution by load proportioning method |
| Individual formative exercises – pipe network calculations for pipework emissions, proportional flow rates and temperature distribution within heating circuits |
| Whole-class teaching – pipework resistance, identification of index circuits, determining frictional resistance in straight pipe, determining the additional pressure loss caused by fittings, calculating total resistance of index circuits, calculation routines and procedures, use of spreadsheets and calculation proformas, producing balanced circuits and absorbing excess pressure at branches, commissioning data for pipework circuits |
| Individual formative exercises – pipe network resistance calculations, additional resistance required to balance circuits, selection of commissioning valves |
| Whole-class teaching – pump duties, application of margins, criteria for selecting pumps for efficiency and performance; prevention of cavitation. Production of pump schedules and commissioning data for selected pumps |
| Learner exercise – determine pump duty from circuit data, select pumps and extract data |
| Whole-class teaching – interpreting manufacturer data for heat emitters, correction of heat output with variation in temperature difference, hydraulic resistance from manufacturer data, production of heat emitter schedules |
| Determining total boiler load, number of boilers, boiler types, fuels, fuel supply requirements, combustion air ventilation, strategies for reducing carbon dioxide emissions, overview of operating principles of CHP, heat pumps, other heat generators |
| **Assignment 4: Sizing and Selection of Pipework and Plant** |
| Review of unit and assignment feedback |

## Assessment

Evidence for this unit may be gathered from a variety of sources but the unit has been written to allow all the assessment evidence to be produced from well-designed project-based assignments on the detailed design of LTHW heating installations for a real building.

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, 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 selected buildings are not too complex, such that LTHW heating installations would not be a realistic solution. Large domestic, low-rise commercial and small industrial buildings would be appropriate. In order to maintain the freshness and rigor of the assessment process, centres should avoid using the same buildings year-on-year.

Learners should be given a range of architectural drawings for them to extract the required information. These could be some or all of plans, elevations, sections and/or details. Drawings should be supported by a simple client brief to provide background information on both the client and their aspirations and the functional requirements for the building.

Where the buildings are large with considerable duplication and repetition, such as three or four storey multi-activity buildings, learners could work in teams to share the workload. This approach can have many benefits but centres must ensure that all learners address all the grading criteria, and that each learner is assessed on their own work and is not disadvantaged by the poor performance of other members of their team.

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 studying other units concurrently, assessment evidence is coordinated to avoid duplication.

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 and 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 12 pass criteria listed in the grading criteria grid.

For P1, learners must assimilate information provided via drawings and client briefs to complete an appraisal of a building and establish its heating needs. The appraisal should consider the form, fabric and function of the building itself and characteristics and requirements of the client and their end users.

For P2, learners must establish heating system design data and parameters for buildings. These should include operational activities, features and usage of the building in general and individual locations. Learners must select the degree of exposure, and the external and internal design temperature appropriate for the particular application and link them to the identified needs. In each case, they must support their selections by indicating the sources of reference used and all the factors used in their selection. Assessment for P2 must extend beyond the mechanistic use of standard tables. In achieving P2, learners should not be assessed on their depth of understanding of human thermal comfort factors (these are assessed elsewhere) but they should refer to these factors when exercising judgement in selecting design temperatures. The buildings specified for assessment must contain locations where a degree of judgement is required. Evidence could be in the form of a presentation or a report supported by appropriate data and tables.

For P3, learners must build on evidence provided for P2 to establish the thermal performance properties of the building fabric and the infiltration rates associated with the building.

For P4, learners must determine heating losses for locations and buildings. They should identify the thermal properties (U values) of the structural elements used in a building together with the infiltration rates. Learners must calculate the steady state heat losses using standard manual 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. Learners may wish to use spreadsheets or proforma calculation sheets to perform these calculations. This is to be encouraged but learners must demonstrate that they understand the principles and procedures involved.

U values used by learners must reflect accurately the construction elements used in the building and should include those requiring the interpretation of standard sources of reference as well as those that have to be calculated. In achieving P4, learners should not be assessed on their understanding of the principles of heat transfer or the fundamental thermal properties of materials as these are assessed elsewhere. Emphasis should be on learner ability to obtain appropriate data (either from reference sources or by calculation) and apply this to determine realistic and reliable heat losses.

For P5, learners must describe the operational characteristics of LTHW heat emitters, pumps, boiler plant and heat generators, pipework and ancillary equipment.

For P6, learners must explain how the operational characteristics described in P5 influence and contribute to their typical application. To achieve P6 learners are not required to exercise judgement in relating the characteristics to a particular application or to make comparisons between different types of plant.

For P7, learners must produce functional and workable designs for LTHW heating installations incorporating pipework circuits and, because the pipes connect to heat emitters, to those heat emitters.

For P8, learners must complete the designs by planning for boilers and heat generators. This must include reference to the fuel, pipework system, feed and expansion arrangement, circulation pump(s) and other ancillary equipment for the given application. Learners are not required to justify or explain their selection but the items selected must be feasible and fundamentally fit for purpose. Learners must show that factors such as the type of circuit, pipework routing, accommodation and appearance have all been considered. In presenting their designs, learners must include appropriate layout and basic pipework schematic drawings. It is essential that the design produced is workable and appropriate to the specific building.

For P9, learners must produce appropriate design drawings to support the evidence for P7 and P8.

For P10, learners must select appropriate design parameters for LTHW heating distribution networks and perform the necessary calculations to determine pipework sizes, flow rates, temperature distributions and resistances, using recognised procedures. The size of the circuits within the network should be representative of those used for P7, P8 and P9. Industry-standard software may be used for procedures but this should be used to support and check manual calculations, not to replace them. Learners may wish to use spreadsheets or proforma calculation sheets to perform these calculations. This is to be encouraged but learners must demonstrate that they understand the procedures involved. In achieving P10, learners are not required to demonstrate their understanding of the underpinning principles of fluid flow in pipes as these are assessed elsewhere. They are, however, required to demonstrate the ability to apply recognised standard procedures derived from these principles. Evidence could be in the form of a report or presentation supported by calculations and diagrams as appropriate.

For P11, learners must size and select appropriate makes and models of LTHW pumps. Calculations appropriate to the selection of each item of plant must be completed where necessary. It is implicit that learners will use manufacturers' information and data to support their selection but there should be evidence that learners understand the procedures used. Learners must comment on the environmental implications of their selection in terms of efficiency, energy requirements and emissions. Evidence could be in the form of a report or presentation supported by calculations, diagrams and manufacturers' data as appropriate.

For P12, learners must specify the size of, and select, appropriate makes and models of LTHW boilers and other ancillary equipment for given heating installations. Calculations appropriate to the selection of each item of plant must be completed where necessary. It is implicit that learners will use manufacturers' information and data to support their selection but there should be evidence that learners understand the procedures used. Learners must comment on the environmental implications of their selection in terms of efficiency, energy requirements, emissions and materials. Evidence could be in the form of a report or presentation supported by calculations, diagrams and manufacturers' data as appropriate.

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

For M1, learners must recommend methods to achieve energy reductions in specified systems. This should include evidence of understanding of why this is of the highest importance and what the consequences of failing to address energy reductions may be. The evidence could include relevant legislation, energy efficiency standards or assessment procedures aimed at limiting heat losses and reducing carbon dioxide emissions, relevant to the particular application. Learners must also recommend methods of achieving energy reductions and assess the effectiveness of these methods. They are not expected to evaluate compliance with every stage or aspect of the legislation, energy efficiency standards or assessment procedures, but they must provide evidence that they can relate the requirements of these constraints to available details from the building under consideration. This is a natural extension of the work carried out for P1, P2 and P3.

For M2, learners must compare different types of LTHW heating plant and make valid and appropriate recommendations as to the most feasible and suitable for specific heating applications. Learners must demonstrate judgement in making their selections and should relate their decisions to the identified needs of particular clients and buildings, and to the performance-in-use of a range of heat emitters. They must explain any constraints and environmental considerations which may have influenced their recommendations. This is a natural extension of the work carried out for P5 and P6.

For M3, learners must evaluate designs for LTHW heating installations, including plant and control arrangements. 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, client requirements and the need for maintenance and commissioning. Any drawings should include detailed layout and schematic drawings. All drawings and reports must be well produced, detailed, annotated and unambiguous. This is a natural qualitative extension of the work carried out for P7, P8 and P9.

For M4, learners must use calculations, installation drawings and manufacturers' data to produce detailed schedules and commissioning data for pipework distribution networks, heat emitters, pumps, boilers and other ancillary components. For the distribution network learners must include the effect of pipework emissions, proportional flow rates for each section, pipe sizes, flow, return and mean water temperatures at various locations, and index circuit resistance. They 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 work carried out for P10, P11 and P12.

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 justify the design rationale used in the production of a heating design, demonstrating 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 design review, 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 M3.

For D2, learners must justify the design principles used in the sizing and specification of heating pipe networks, plant and components. They must show how the proposed selections satisfy the specified performance requirements. In justifying the design parameters learners must explain clearly why they used particular parameters, what alternative parameters could have been used and the effect of using other parameters. For plant and components, learner justification should establish appropriate performance standards and show whether the selected items of plant and equipment 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 M4.

### 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, P3, P4, M1 | Client Needs, Design Data and Heat Losses | As a heating design and installation engineer, you have been asked to complete the initial stages of the design process for a heating installation. Within the detailed client brief there is the specific requirement for you to complete the pre-design information, gather design data and complete the thermal analysis stages of the design process. | A report supported by drawings, images, graphs, tables, charts and calculations as appropriate. |
| P5, P6, M2 | Operational Characteristics of LTHW Systems | The client is keen to know what plant and equipment is being considered for the heating design. You have been asked to complete a manual of the options available, the advantages and disadvantages of each and the reasons why specific items are preferable for the project in question. | A manual or catalogue of the items of plant and equipment from which the final selection will be made, together with recommendations. |
| P7, P8, P9, M3, D1 | Heating Equipment, Feasible Options and Layout Designs | You have been asked to explain to the client the features of the various options available for the items of plant and equipment to be used for the heating system for a building. You must also recommend what you believe to be the most appropriate heating designs for the building. | Appropriate and detailed heating systems designs. |
| P10, P11, P12, M4, D2 | Sizing and Selection of Pipework and Plant | You have been asked to make the appropriate selections, and perform the necessary calculations, to complete the equipment and plant sizing and selection stages of the heating design. | A report supported by drawings, images, graphs, tables, charts and calculations as appropriate. |

## 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 |
|---|---|---|
| | | Mathematics in Construction and the Built Environment |
| | | Science and Materials in Construction and the Built Environment |
| | | Building Services Control Systems |
| | | Building Services Science |
| | | Fluids – Static and Dynamic in Building Services Engineering |

- This unit links with Summit Skills N/SVQ Level 3 Building Services Engineering Technology and Project Management, in particular Unit TPM3/003: Apply Design Principles to Building Services Engineering Projects and Unit TPM3/007: Provide Technical and Functional Information to Relevant People. It also links to the Level 3 National Occupational Standards in Built Environment Design.
- This unit may also contribute to Summit Skills N/SVQ Level 4 Building Services Engineering Technology and Project Management, in particular Unit TPM4/004: A Working Understanding of Mechanical Engineering Services Technology and Unit Project Design Recommendations and Unit TPM4/008: Develop and test building services engineering project design solutions, and Unit TPM9/009 Prepare and advise on building services engineering project design recommendations.

## Essential resources

Centres should have access to a wide range of hard copy or online technical and manufacturers' literature.

The use of readily available visual aids (such as the range of heating plant and components indicated in learning outcome 2) would be advantageous. These can be in the form of either individual items and/or as part of live installations. Where live installations are used the requisite risk assessments must be completed.

Centres should have access to sets of architectural drawings, heating system installations and schematic drawings to support the learning process and facilitate assessment. These could be in hard copy or electronic format. Where these drawings are used as part of the assessment process, it is recommended that repeated use of the same building is avoided in order to maintain the freshness of the assessment process.

Learners may 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 can complete the calculations required in learning outcomes 1 and 4 using recognised manual procedures. The same principle applies to the graphical detailing required for learning outcome 4.

## 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:

- Chartered Institution of Building Services Engineering – www.cibse.org
- Heating and Ventilation Contractors Association – www.hvca.org.uk
- 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
- Summit Skills – www.summitskills.org.uk
- 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


BSRIA – *A Guide to HVAC Building Services Engineering Calculations* (BSRIA, 2007) ISBN 9781903287910

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

Chartered Institution of Building Services Engineers – *KS8 How to Design a Heating System* (CIBSE, 2006) ISBN 10: 1903287790

Chartered Institution of Building Services Engineers – *B1 Heating* (CIBSE, 2002) ISBN 1903287200.

Chartered Institution of Building Services Engineers – *Guide A: Environmental Design, 7th Edition* (CIBSE, 2006) ISBN 1903287669

Chartered Institution of Building Services Engineers – *Guide F: Energy Efficiency in Buildings* (CIBSE, 2004) ISBN 1903287340

Chartered Institution of Building Services Engineers – *KS7: Variable Flow Pipework Systems* (CIBSE, 2007) ISBN 9781903287774

Chartered Institution of Building Services Engineers – *KS14: Energy Efficient Heating* (CIBSE, 2009) ISBN 9781903287989

Chartered Institution of Building Services Engineers – *KS10: Biomass Boilers* (CIBSE, 2007) ISBN 9781903287866

Chartered Institution of Building Services Engineers – *Introduction to Sustainability* (CIBSE, 2007) ISBN 9781903287811

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, 10th Edition* (Butterworth-Heinemann, 2008) ISBN 9780750683654

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


### Journals


*Building Services Journal* – CMP Information

*Building Services and Environmental Engineer* – Datateam Publishing Ltd

*Modern Building Services* – Portico Publishing Ltd

**Websites**

| | |
|---|---|
| www.bsria.co.uk | The Built Environment Experts |
| www.cibse.org | Chartered Institution of Building Services Engineers |
| www.modbs.co.uk | Modern Building Services |

There are a wide range of manufacturer websites which are useful resources.

## Delivery of personal, learning and thinking skills (PLTS)

The following table identifies the PLTS opportunities that have been included within the assessment criteria of this unit:

| Skill | When learners are ... |
|---|---|
| **Independent enquirers** | assimilating and analysing information provided by drawings and client briefs to identify the heating needs<br>making decisions and exercising judgement on design conditions<br>appraising the heating needs of a building from the perspective of the client, end user and legislation<br>resolving problems relating to heat losses from buildings<br>exercising judgement when extracting information from drawings and design guides to select appropriate U values and infiltration rates<br>researching the operational features and characteristics of heating plant<br>analysing and concluding how the features and characteristics of heating plant and equipment affect their application<br>using judgement to select the most appropriate forms of heating plant<br>solving problems associated with designing workable LTHW layouts<br>exploring appropriate pipework configurations for different heat emitter possibilities<br>using information to select heating plant and design functional layouts<br>resolving problems associated with pipework flow rates, sizes and consequent resistances<br>selecting the pipework design parameters and judging the consequences of their decisions<br>analysing pipework circuits and selecting appropriate data required for the network analysis<br>solving problems in relation to sizing plant appropriate to specified installations<br>researching manufacturer's performance data to identify appropriate items<br>analysing manufacturer's data and exercising judgement to select heating plant to match calculated requirements<br>considering how the environmental implications of the plant and equipment influenced their selection<br>providing evidence for the conclusions reached for the selected plant |
| **Creative thinkers** | generating designs and heating proposals for buildings and considering alternative strategies and approaches<br>researching heating plant and equipment to establish potential applications<br>producing innovative designs based on research and case studies<br>challenging pre-conceived or standard solutions for heating installation designs when considering feasible options<br>refining designs to try out alternative strategies |

| Skill | When learners are ... |
|---|---|
| **Reflective learners** | assessing their own progress and performance against the grading criteria within Assignments 1,2 and 3<br>programming and scheduling the work required for the successful completion of Assignments 1, 2 and 3 against targets deadlines<br>reviewing their own progress against programmes and work schedules and adjusting the programme accordingly<br>dealing with feedback and criticism as a result of submitted work and formative exercises<br>reflecting on feedback from Assignments 1 and 2 and using the information to improve their performance in Assignments 2 and 3<br>making verbal, graphical and written presentations to both formal and informal audiences |
| **Team workers** | using a teamwork approach for Assignments 1, 2, or 3 or where they work with others on formative exercises, opportunities exist for the following<br>collaborating with others in establishing standards, design data and approaches which are common to all members of the team or common to the building being considered<br>meeting and working effectively together as members of a team to reach agreements and resolve issues<br>identifying and participating in the various roles and responsibilities that exist within the teamwork situation<br>working considerately, responsibly and effectively with other members of the team |
| **Self-managers** | working towards and completing assignments against deadlines and using initiative to resolve problems and issues<br>producing and following a programme and work schedule for the completion of Assignments 1, 2 and 3 against set deadlines<br>balancing the competing pressures of their responsibilities at work and at home in order to successfully complete the assignments |
| **Effective participators** | using a teamwork approach for Assignments 1, 2, or 3 or where learners work with others on formative exercises<br>resolving issues and concerns that arise within the team in a way that is acceptable to all members<br>discussing, agreeing and planning progression in a manageable way<br>establishing working practices and improvements within the team |

## 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 | selecting and using appropriate software and ICT applications for the reports, research, data management, designs, graphical detailing, calculations, and presentations implicit within assignments |
| Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used | using ICT applications for planning assignments and reviewing the ICT applications used within the assignments |
| Manage information storage to enable efficient retrieval | maintaining the files and data produced when completing assignments in an efficient and effective way |
| Follow and understand the need for safety and security practices | completing the ICT tasks for assignments |
| Troubleshoot | completing the ICT tasks for assignments |
| **ICT – Find and select information** | |
| Select and use a variety of sources of information independently for a complex task | selecting and using information and data from web-based reference sites, e-publications, manufacturer's technical data, standards, guides and publications, graphical images etc for use within assignments. Appropriately referencing sources of information used |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | effectively accessing, selecting, evaluating fitness for purpose and using data, standards, legislation manufacturer's information, images and reference material via search engines, online reference sites and browsers when completing assignments |
| **ICT – Develop, present and communicate information** | |
| Enter, develop and format information independently to suit its meaning and purpose including:<br>• text and tables<br>• images<br>• numbers<br>• records | completing assignments to include appropriate use of correctly formatted, structured, justified and presented:<br>• text for descriptions and explanations etc.<br>• tables for recording results, data and schedules etc.<br>• images from manufacturer information and CAD drawings etc.<br>• numerical information presented as formulae (with solutions) and spreadsheet(s) for the calculation of U values, heat losses, areas and volumes, pipe loading and sizing, network resistances etc.<br>• records presented as graphs, schedules, or spreadsheets for the calculated results required for plant selection and commissioning data etc |
| Bring together information to suit content and purpose | assembling the various components (text, images, tables, drawings, spreadsheets, records, charts, and calculations etc) implicit for assignments in a format appropriate for the mode of assessment ie report, portfolio and/or presentation |

| Skill | When learners are ... |
|---|---|
| Present information in ways that are fit for purpose and audience | reviewing and editing the various components (text, images, tables, drawings, spreadsheets, records, charts, and calculations etc) implicit for assignments so they are fit for purpose for the audience and mode of assessment ie report, portfolio and/or presentation |
| Evaluate the selection and use of ICT tools and facilities used to present information | reviewing the suitability and performance of the ICT tools used during the completion of assignments, taking action as appropriate |
| Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists | communicating and exchanging information via email or elearning platforms with staff, colleagues, other team members or manufacturers during the completion of assignments |
| **Mathematics** | |
| Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations | calculating U values using standard formulae<br>using scales to determine dimensions from drawings<br>calculating surface areas for a variety of sizes and shapes of building surfaces<br>calculating room and building volumes<br>calculating heat losses using positive and negative numbers<br>calculating flow rates in pipe distribution networks to meet heat output requirements<br>interpolating within graphs and tables to obtain data<br>calculating heat emissions from pipework and equipment under different operating conditions<br>calculating temperature distributions within pipe distribution networks<br>calculating frictional resistances for index circuits and additional resistance required to balance branch circuits<br>using area and velocity ratios to determine pressure loss factors for pipework fittings<br>applying percentage margins for plant selection<br>applying correction factors to plant performance data to allow for varying operating conditions<br>calculating linear expansion in pipework and volumetric expansion in water<br>using formulae in all of the above |
| 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 | using estimating and analytical techniques to check the reliability and appropriateness of mathematical results. ie comparisons with 'rules of thumb', average results such as w/$m^2$ or w/$m^3$ for average heat loss Pa/m for pump duties etc recognising sensible answers |

| Skill | When learners are ... |
|---|---|
| Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations | using solutions obtained from calculations to select and specify plant and equipment and check compliance with standards |
| Draw conclusions and provide mathematical justifications | analyse calculations to establish performance data for plant and equipment<br><br>using mathematical techniques to justify design data and rationale |
| **English** | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | contributing to formal and informal presentations and discussions as part of formative exercises on the operating characteristics of plant and equipment etc, and as part of formal presentations for assignments |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | reading design guides, standards, legislation, approved documents, textbooks, course notes, manufacturer information, websites, technical standards, design briefs, application manuals, technical memorandum etc, in order to gather information to complete assignment 3 |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | producing portfolio(s), reports and presentations implicit in assignments. |