

Domestic heating by gas:
boiler systems – guidance
for installers and specifiers

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1. Introduction to best practice

Home energy use is responsible for over a quarter of UK carbon dioxide (CO₂) emissions which contribute to climate change. To help mitigate the effects of climate change, the Energy Saving Trust has a range of technical solutions to help UK housing professionals build to higher levels of energy efficiency.

This guide is designed to help installers, specifiers and purchasers of domestic central heating systems to select the most suitable system for their needs. It gives advice on how to achieve better energy efficiency, lower running costs and reduced CO₂ emissions.

This publication is particularly concerned with the encouragement of best practice. While the requirements for satisfying building regulations in various parts of the UK are described, the main purpose is to explain how to achieve better performance through careful choice of systems and practices.

This publication focuses on wet or hydronic central heating systems in which the water is circulated to heat emitters from a gas boiler. 'Gas' in this context means natural gas or Liquefied Petroleum Gas (LPG). Other guides in this series deal with systems containing oil and solid fuel boilers.

This publication specifically addresses issues concerning the selection of boilers, hot water storage vessels, controls and indeed complete systems. It brings together information on most types of boiler currently available, the systems to which they can be fitted and key points to consider when choosing equipment for a particular installation. It concentrates on the use of condensing boilers since it is no longer acceptable to fit non-condensing boilers in most cases for both new or replacement situations.

How to use this guide

The guide is set out as follows:

Section 2 explains the building regulations for heating and hot water systems in different parts of the UK.

Sections 3, 4 and 5 go into some detail about the range of systems, boilers and controls currently available.

Section 6 reproduces the Central Heating Systems Specifications (CHeSS). These set out specifications for meeting the basic efficiency levels needed to comply with building regulations as well as higher performance levels regarded as current best practice. They can be used as ready-made purchase specifications.

Section 7 focuses on the benefits to be obtained from choosing best practice.

Section 8 covers the practical issues affecting the selection of boilers, systems and controls.

Section 9 is concerned with proper installation, especially with regard to the flues and drains needed for condensing boilers, as well as the installation of controls.

Section 10 offers guidance on commissioning and other related issues such as servicing and information to be provided to customers.

The appendices provide additional notes to the CHeSS specification, together with definitions of different boiler types and controls.

Note: the superscript numbers in brackets in the text refer to documents listed at the end of this guide.

Introduction to best practice

1.1 Boiler efficiency

The efficiency of the boiler is the main factor in the overall efficiency of a domestic central heating system. This is why minimum standards of efficiency are required by law for most boiler types. UK building regulations requires a higher performance than the EU Boiler Efficiency Directive⁽¹⁷⁾ but best practice requires boilers of even higher efficiency to be selected.

In turn, the efficiency of the overall system has a major impact on running costs and the associated CO₂ emissions. Boiler efficiency depends upon:

- Fuel
- Boiler type and design
- Ignition system (automatic or permanent pilot).
- Burner control (on/off, gas modulating, air/gas modulating)
- The load on the boiler due to the weather
- Boiler and radiator sizing relative to the design heat load
- System controls
- Flow and return temperatures
- Installation and commissioning
- System free of sludge and scale
- Regular servicing and maintenance.

The advances in boiler technology mean that when older boilers are replaced, substantial efficiency improvements can be expected from newer equipment. Manufacturers now design for maximum efficiency consistent with durability. The greatest energy efficiency benefits are obtained from installing condensing boilers. These are always more efficient than non-condensing models. It is now a requirement of the building regulations that newly installed gas-

Why are condensing boilers more efficient?

A condensing boiler has a large heat exchanger (or, in some designs, a second heat exchanger) that extracts more heat from the flue gases. In a non-condensing boiler, the flue gases are at a temperature of 120-200°C. In a condensing boiler, more heat is removed and the temperature falls to below 100°C and as low as 50°C for the most efficient boilers operating at reduced boiler return temperature. The water vapour in the gases condenses (hence the name) and the resulting liquid has to be drained away. As the 'flue gas' side of the heat exchanger gets wet in the process, it is more susceptible to corrosion. To avoid this, it has to be constructed from corrosion-resistant materials e.g. stainless steel or aluminium. For more information on different boiler types (see Section 3).

fired boilers should be condensing (excludes range-cooker boilers), with a SEDBUK (Seasonal Efficiency of a Domestic Boiler in the UK) efficiency of 86% or more, unless exceptional circumstances apply (see Section 2.2).

1.2 Energy consumption and emissions

Boilers consume far more energy than household appliances. In the UK the average dwelling with central heating uses about 23,000 kilowatt-hours (kWh) of energy each year, of which about 85% is for heating and hot water. To reduce fuel costs and emissions it is important to choose the most efficient boilers and install them in suitably designed and controlled systems.

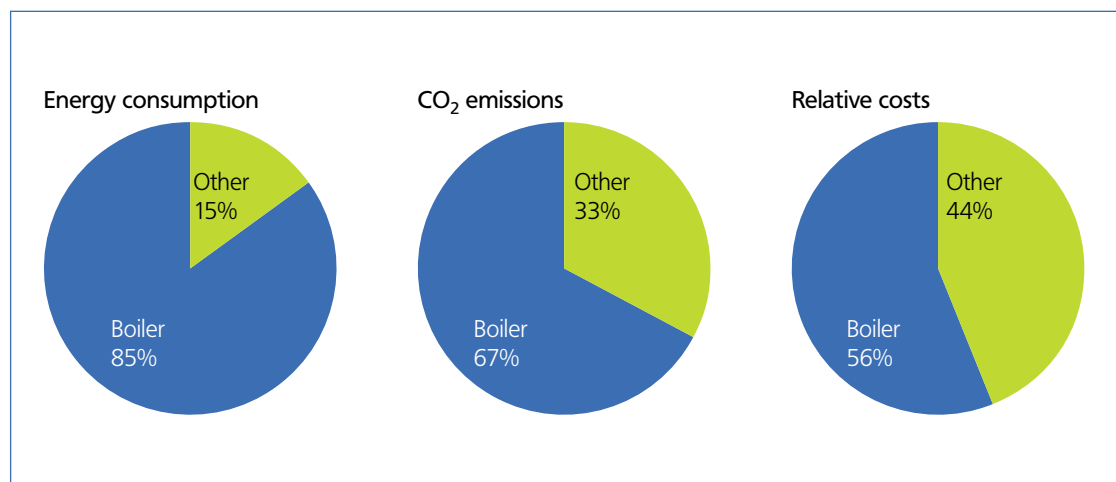


Figure 1: Heating and hot water as a proportion of total energy usage in homes heated by natural gas

Introduction to best practice

1.3 Environmental impact of gas heating

Gas relative to other fuels

The main environmental impact of heating systems is the emission of CO₂. The CO₂ emissions from burning natural gas are low in comparison with most other fuels, though higher than from biomass (e.g. wood). Emissions from LPG are about 21% greater than those from burning natural gas to give an equal amount of heat. However, it is possible to obtain slightly higher efficiencies from LPG boilers, so for the same amount of useful heat output from a boiler the CO₂ emissions are approximately 18% higher.

Alternatives to gas heating

Alternatives that may have a lower environmental impact should be considered where practicable. Possible alternatives include wood-burning boilers, and micro-CHP units. Micro-CHP, while burning gas, produces electricity as a by-product that offsets the carbon burden of central generation.

Where a gas heating system is chosen, fuel consumption and carbon emissions can be reduced by combining it with solar water heating (see Section 4.3).

2. UK building regulations

2.1 Introduction

This section outlines the minimum standards for heating efficiency as set out in the building regulations. The remainder of this guide then concentrates on best practice – a higher standard.

The building regulations set a legal requirement to make 'reasonable provision... for the conservation of fuel and power in dwellings'. However, the approved guidance makes clear that there may well be alternative ways of achieving compliance, and different strategies can be adopted provided it can be shown they are at least as good as those already accepted as reasonable provision.

There are different building regulations* in England and Wales, Scotland, and Northern Ireland. They restrict the types of heating system that may be installed in both new and existing dwellings. The different regulations in each country are summarised in later sections, but for details reference should always be made to the official documents^(18,19,20).

For new dwellings the general approach is to demonstrate compliance by showing that the carbon emissions are below a given threshold for a particular dwelling. There are also minimum SEDBUK efficiencies that apply to gas and LPG boilers. The efficiency of the particular make and model of boiler installed is used in the calculation of carbon emissions for individual dwellings.

For existing dwellings there are minimum requirements for boiler efficiency, hot water storage vessels, pipe insulation, controls, and commissioning that apply when heating systems are replaced or modified.

In England, Wales and Northern Ireland detailed guidance on the minimum requirements for heating and hot water systems is given in the Domestic Heating Compliance Guide⁽²¹⁾. This guide was prepared with support from industry and offers specific information on how to achieve compliance. In Scotland the detailed guidance is incorporated in Technical Standards handbooks⁽¹⁹⁾.

* This guide outlines the relevant building regulations in England, Wales, Scotland and Northern Ireland. Regulations that apply in Jersey, Guernsey and the Isle of Man are broadly similar but it is essential to refer to official guidance.

Other parts of the regulations deal with the related issues of the safety of heating installations and with fuel storage. They are Part J (England and Wales), Section 3: Environment (Scotland) and Technical Booklet L (Northern Ireland). Requirements for sealed (unvented) systems are in Part G (England and Wales), Section 4: Safety (Scotland) and Technical Booklet P (Northern Ireland).

2.2 General requirements

Calculation of carbon emissions

The Government's Standard Assessment Procedure (SAP), see below, is used to calculate the energy and environmental performance ratings and carbon emissions of individual dwellings. To comply with building regulations, a new dwelling must have carbon emissions that do not exceed a target value. Compliance is established by calculating a Dwelling Emission Rate (DER) and Target Emission Rate (TER) – see box on page 7. There are some differences in the way that DER and TER are calculated and applied in each country, and for more information reference should be made to the respective regulations or standards^(18,19,20).

Whilst this guide is concerned with gas-fired heating and hot water systems, renewable energy should also be considered. The use of technologies such as solar water heating (see Section 4.3) will reduce the DER.

Standard Assessment Procedure (SAP)

SAP is the UK government's procedure for the energy rating of homes⁽²²⁾. The properties of a building, such as the insulation, determine its heat requirements, while the type of heating system and heating fuel determine the energy use, cost and CO₂ emissions under standard occupancy conditions.

In the latest version, SAP 2005, the rating scale is 1 to 100. This is based on the calculated cost of space and water heating, ventilation and lighting, less savings from any energy generated in the building. High numbers represent better energy performance, and a rating of 100 is reached when the net energy consumption (over a whole year) is zero. Ratings above 100 are possible when the dwelling is a net exporter of energy. To comply with building regulations all new homes must have a SAP assessment. SAP also calculates the environmental impact (CO₂) rating, the dwelling emission rate (DER) and the target emission rate (TER).

Environmental Impact (CO₂) rating, and Environmental Impact (CO₂) band

The Environmental Impact (EI) rating is a number representing the annual CO₂ emissions, calculated as part of the SAP procedure. Higher numbers represent lower emissions, with 100 representing zero net emissions. Numbers above 100 are possible if the dwelling is a net exporter of energy. The number range is divided into bands labelled A to G that are intended for use on building energy certificates.

Boiler efficiency

SAP 2005 uses SEDBUK (Seasonal Efficiency of Domestic Boilers in the UK) boiler efficiencies to calculate the energy required to meet the heating demand of the building. Only SEDBUK efficiency figures are acceptable and the best source of this information is the Government's Boiler Efficiency Database. See www.boilers.org.uk

The current minimum efficiencies for gas fired boilers are shown in table 1.

Condensing boilers are required in most cases except where the installation would be impractical or excessively costly. In these cases it may be reasonable to install a non-condensing boiler instead (see box – condensing boiler exceptions). The procedure is referred to as 'Assessing the case for a non-condensing boiler' in England, Wales and Northern Ireland and 'Condensing Boiler Installation Procedure' in Scotland.

Table 1: Minimum efficiency (SEDBUK) requirements – UK building regulations

	New dwellings	Existing dwellings
Regular boilers	86%	86%
Combination boilers	86%	86%
Range cooker/boilers*	75%	75%

* The cooker and boiler must have two independently controlled burners

Dwelling emission rate (DER) and target emission rate (TER)

The DER and TER are calculated as part of the SAP procedure. The DER gives the CO₂ emissions per unit of floor area, expressed in kg/m²/year. To comply with building regulations in England and Wales, the DER of a new dwelling must not exceed a target value (TER). The TER is calculated for a notional dwelling of the same size and shape, and varies with choice of fuel.

Condensing boiler exceptions

To determine the conditions under which a non-condensing boiler is accepted as reasonable, an assessment of the property should be carried out. Details are given in (19,21). There is an assessment form, with instructions for completion, and a technical guide(23,24). Key points include the following:

- The assessment considers fuel type, dwelling type, boiler position, flue options, flue terminal positions and condensate drain points.
- The lowest cost installation position must be found, as defined by the procedure.
- Standardised costs and benefits are assumed, which will not be the same as actual costs and benefits in any particular property.
- The installation position is based on the characteristics of the empty building, ignoring furniture and fittings as well as any position preferred by the owner.
- A simple points system determines whether the lowest cost installation option exceeds a fixed threshold.
- The assessment form must be completed and signed by a competent person and a copy given to the building owner, who should retain it as evidence an assessment has been carried out.
- If confirmed by the assessment, a non-condensing boiler may then be installed. The assessment form may be needed as evidence when the building is sold.
- Even when an exception is allowed, a condensing boiler is preferable and a grant may be available to the householder to assist with the extra installation cost.
- The boiler installed, whether condensing or non-condensing, does not have to be installed in the position evaluated for the purpose of the assessment.

UK building regulations

Storage vessels

Hot water storage vessels should be insulated in accordance with BS 1566:2002⁽²⁵⁾, and the internal heat exchanger should be sized accordingly. They must also have a label showing type, capacity, heat loss and performance.

There should be pumped circulation through the primary circuit to the heat exchanger.

System circulation

Both heating and hot water domestic primary circulation systems should have pumped circulation. Existing semi-gravity systems should be converted to fully pumped.

Controls

Zone controls should allow different air temperatures to be set for living and sleeping areas (other than in small open-plan flats and other properties where these areas are not separated).

In most dwellings, both temperature zones can be controlled by a single time switch or programmer channel. However, in properties with a floor area of more than 150m², multiple timing zones are required (with no zone larger than 150m²).

Separate timing control should be provided for hot water, unless this is provided by a combi boiler.

Boiler interlock (see Section 5.1) is needed to ensure that the boiler and pump is switched off when neither heat nor hot water is wanted. Thermostatic radiator valves (TRVs) alone do not provide boiler interlock. They must be supplemented by a room thermostat or similar device to turn off the boiler and prevent unnecessary boiler cycling.

A bypass circuit of specified minimum length should be provided if the boiler manufacturer's instructions require it, in which case it should be fitted with an automatic bypass valve.

Pipework

Pipes should be insulated wherever they pass outside the heated living space. In addition, all hot water pipes connected to the hot water cylinder (including the vent pipe and the primary flow and return) should be insulated for at least 1m from the connection. Pipework in unheated areas must be insulated to meet requirements to limit heat loss.

Electrical Works

All electrical works must be carried out to BS 7671⁽²⁶⁾.

Existing buildings

New or replacement hot water storage vessels and controls should meet the same requirements as in new buildings.

Commissioning

Upon completion of the installation, the system should be inspected and then brought into service so that it operates efficiently and meets its specified performance levels. The owner or occupier should also be given information on the operation and maintenance of the system. Further information on the requirements for commissioning and handover can be found in the Domestic Heating Compliance Guide (England, Wales and Northern Ireland) and in the Technical Standards handbook (Scotland).

2.3 England and Wales

General

There are two Approved Documents⁽¹⁸⁾ ADL1 (new dwellings) and ADL2 (existing dwellings) that outline basic requirements, and they are supported by more detail given in the Domestic Heating Compliance Guide⁽²¹⁾.

Further information is available from the Communities and Local Government (CLG) planning portal website www.planningportal.gov.uk

Hot Water

Hot water storage vessels should be insulated in accordance with BS 1566, BS 3198 or BS EN 12897^(25,27,28), and the internal heat exchanger should be sized accordingly. There should be pumped circulation through the primary circuit to the heat exchanger. If a thermal store is used, it should meet the requirements of the Waterheater Manufacturers' Association 1999 performance specification⁽²⁹⁾.

They must also have a label showing type, capacity, heat loss and performance.

Electrical works

In addition to the requirements of BS 7671, certain electrical works are regarded as controlled services and should only be carried out by a competent person and notified by the competent person scheme to which they belong.

UK building regulations

Commissioning

Upon completion of the installation, the system should be inspected and then brought into service so that it operates efficiently and meets its specified performance levels. The owner or occupier should also be given information on the operation and maintenance of the system. The installer (competent person) should provide details of the installation to the operator of the competent person scheme who will send a certificate to the householder and supply any relevant information to the local authority building control department. Alternatively installers or their customers can use the local authority building control route for building regulation notification for which a charge is made.

Existing buildings

Approved document ADL2 specifies requirements for existing buildings. There are no TER and DER calculations required but when the work involves the provision or upgrade to a heating or hot water system, it must follow the requirements given in the Domestic Heating Compliance Guide⁽²¹⁾.

In particular, any new boiler (whether or not it replaces an existing unit) should meet or exceed the minimum efficiency requirements given in table 1. Where the installation of a condensing boiler would be impractical or excessively costly, it may be reasonable to install a non-condensing boiler instead (see boiler exceptions panel). Replacements should be specified as for new systems and no worse than 2 percentage points lower than the boiler being replaced. Further requirements apply if the replacement involves fuel change.

Most types of heating system are controlled services, including central heating systems with boilers. Alterations to controlled services or fittings require a Building Control Notice, unless they are carried out by a recognised competent person allowed to self-certify the work.

2.4 Scotland

General

New dwellings must comply with the Building (Scotland) Regulations⁽¹⁹⁾ as presented in their technical handbooks (last updated in May 2007).

Requirements for the conservation of fuel and power are given in the domestic handbook Section 6 (Energy). Demonstration of compliance

is based on carbon emissions. SEDBUK efficiencies are used in the carbon emission calculations and minimum efficiency values also apply.

Further information is available from the Scottish Building Services Agency website (SBSA) website www.sbsa.gov.uk

Commissioning

Upon completion of installation, systems must be inspected, tested, and brought into service so as to meet the specified performance and operate efficiently. Written information on the operation and maintenance of the system must be provided to the occupier. A building warrant scheme is used, and it should always be confirmed whether a warrant is required for works involving gas-fired boilers, systems and controls.

Existing buildings

If a central heating boiler is to be replaced in an existing dwelling it is required to meet the minimum SEDBUK efficiency as stated for new systems. Where it is impractical or uneconomic to install a condensing boiler, the dwelling may be assessed as given in the Guide to Condensing Boiler Installation Assessment procedure for dwellings (Scotland)⁽⁵³⁾. Where this assessment confirms a non-condensing boiler can be fitted it should have a minimum SEDBUK efficiency of 78% (natural gas) or 80% (LPG). Alternatively a back-boiler with a SEDBUK of 3 percentage points less than the above figures may be installed.

Existing systems with semi-gravity circulation should be converted to fully-pumped. Replacement boilers should always be fitted with controls as required for new systems. TRVs should be fitted on all radiators in a new building extension, even though the heat may be supplied from an existing boiler. Where only part of a heating system is replaced it should be done in such a way that the energy efficiency is not downgraded.

2.5 Northern Ireland

General

The relevant building regulations are the Building Regulations (Northern Ireland) 2000, and specifically Building Regulations F3 and F4⁽³⁰⁾. These were last amended in 2006 and call for 'reasonable provisions' to be made for space heating and hot water supply.

UK building regulations

The installation, alteration or replacement of any heating system must comply with the relevant regulations. All new heating systems should be notified to building control, and any alteration to an existing heating system where a structural alteration is involved. Where an existing heating system is extended, the extension to the system must be insulated to comply with regulation F4.

Technical Booklet F1: Conservation of fuel and power⁽²⁰⁾ gives provisions that are deemed-to-satisfy the requirements of regulations F3 and F4. Although it is not essential to follow Technical Booklet F1, it is obligatory to comply with building regulations F3 and F4.

Further information is available from the Department of Finance and Personnel, Northern Ireland website www.dfpni.gov.uk

Existing buildings

A new boiler (whether or not it replaces an existing unit) should meet or exceed the minimum efficiency requirements given in table 1 (page 7). Where the installation of a condensing boiler would be impractical or excessively costly, it may be reasonable to install a non-condensing boiler instead (see panel – condensing boiler exceptions on page 7). Replacements should as specified for new systems and no worse than 2 percentage points lower than the boiler being replaced. Further requirements apply if the replacement involves fuel change.

The technical booklets refer to the Communities and Local Government (CLG) publication 'Domestic Heating Compliance Guide'⁽²¹⁾ for requirements on controlled services, insulation of pipes, ducts and storage vessels.

Hot Water

Hot water storage vessels should be insulated in accordance with BS 1566, BS 3198 or BS EN 12897^(25,27,28), and the internal heat exchanger should be sized accordingly. There should be pumped circulation through the primary circuit to the heat exchanger. If a thermal store is used, it should meet the requirements of the Waterheater Manufacturers' Association 1999 performance specification⁽²⁹⁾.

They must also show a label detailing type, capacity, heat loss and performance.

Commissioning

Upon completion of the installation, the system should be inspected and then brought into service so that it operates efficiently and meets its specified performance levels. Local authority building control must be notified of any gas firing, storage, installation and commissioning works.

A building notice confirming that all fixed building services have been commissioned by a suitably qualified person is required and a copy given to the district council and the dwelling owner.

3. Boiler types

While this guide describes all types of gas-fired boilers, it concentrates on condensing units which in most cases must be fitted since building regulations specify them as a minimum requirement.

Condensing boilers provide optimum performance with low running costs and reduced CO₂ emissions.

Natural gas produces the lowest CO₂ emissions per unit of heat delivered and also offers low running costs for a wide range of dwellings. LPG boilers are similar in design and efficiency, but the fuel is considerably more expensive. The additional cost of storage tanks (usually rented from the fuel supplier) also needs to be considered.

When seeking estimates of installation costs for LPG-fired boilers, ensure that the provision and installation of an adequate LPG gas storage tank is taken into account as well.

In most households, a single boiler provides both space heating and hot water, either:

- Indirectly, through a regular boiler and separate hot water tank (which is usually a copper cylinder with a heating coil inside);
- Or
- Directly, using a combination boiler with no separate tank.

3.1 Condensing boilers

Condensing boilers are the only type that meet best practice requirements and should always be considered as first choice in any application. In the UK all gas-fired boilers installed must be condensing (except range cooker-boilers), with a SEDBUK efficiency of 86% or more, unless an exception is allowed (see Section 2.2).

Even if an exception is allowed, a condensing boiler should always be the first choice and a grant may be available to the householder to assist with the extra installation cost.

Features of condensing boilers

- SEDBUK efficiencies between 86% and 97% (with natural gas as the fuel).
- Typically a new condensing gas boiler will have an efficiency of 90%, compared with 80% for a new non-condensing boiler and 55-65% for older types.
- The system does not need to be designed to make the boiler condense all the time to achieve improved efficiency.
- Available in regular and combi models.
- Mostly wall-mounted, although some larger output models are floor standing.
- Only room-sealed, fan-flue models available for domestic applications.
- Most have extended flue options.
- Suitable for replacing most existing boilers (but not back boiler units (BBUs) in the same position).

Installation considerations for condensing boilers

- They are as easy to install as non-condensing boilers, but need a connection from the condensate outlet to a drain.
- Can be installed in modern fully-pumped systems.
- Oversized radiators will increase efficiency but good efficiency can still be obtained with 'normally sized' radiators.
- Care is needed in siting the flue terminal due to the plume of water vapour usually present during boiler operation. The plume will be visible for much of the time the boiler is in operation.
- Can employ a range of extended flue and plume management options, with the visible plume less likely to be a nuisance at high levels.

Boiler types

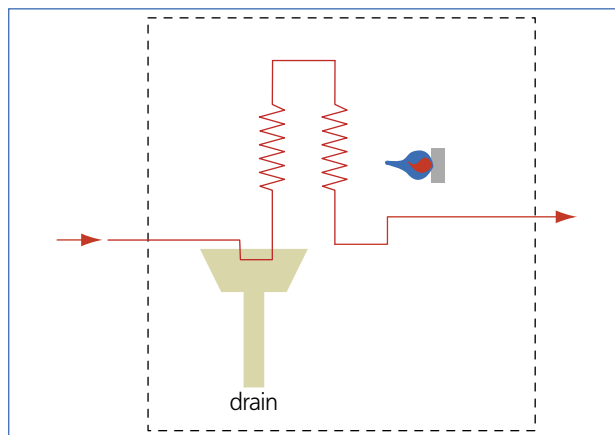


Figure 2: Condensing regular boiler

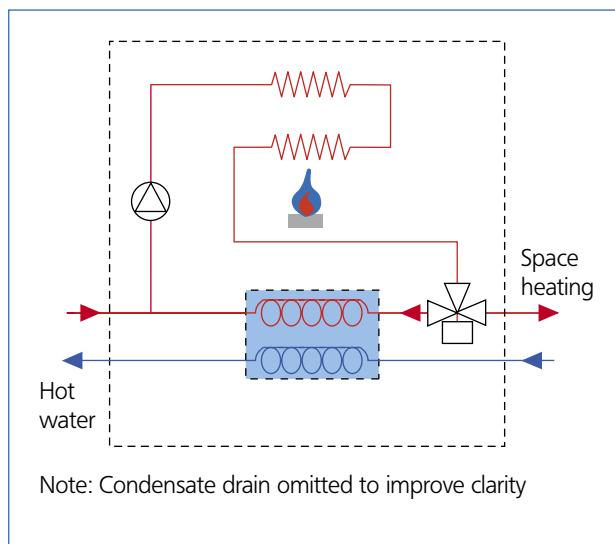


Figure 3: Condensing instantaneous combi boiler

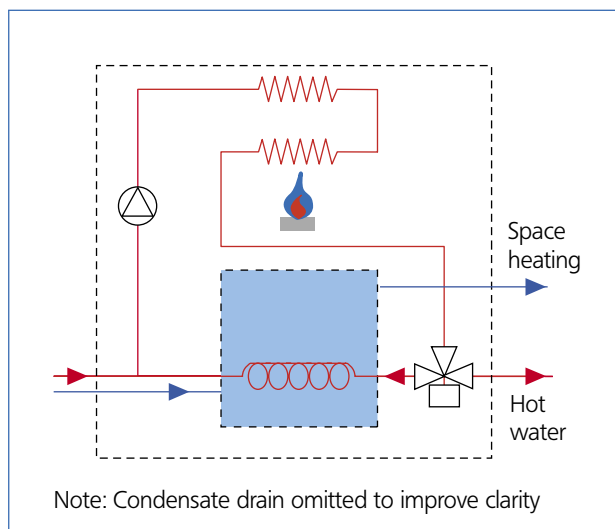


Figure 4: Condensing storage combi boiler

3.2 Regular boilers

Units that are not combination boilers (see below) are commonly referred to as 'regular', or 'heat only' boilers. They can be wall-mounted or floor-standing. Space heating is provided directly, but for hot water they need to be connected to a separate hot water storage system.

A back boiler unit (BBU) is one designed to be installed within a fireplace (condensing BBUs are not available).

Regular boilers for sealed systems (see Section 4.1) which have components such as pumps and expansion vessels within their casings are known as system boilers.

3.3 Combination boilers

Combination or combi boilers provide both space and hot water heating directly. They are available as instantaneous or storage types,

The most common type is the instantaneous combi boiler (figure 3), which heats water on demand and does not maintain a large internal store of already heated water. These boilers are capable of providing a continuous flow of hot water, but most provide a lower flow rate than typical hot water storage systems. Units with a much higher heat output (up to 40kW) have now been introduced which are capable of much higher water flow rates.

The storage types (figure 4) include those with small to medium stores and also CPSUs (see page 13) which can provide very high water flow rates. Higher water flow rates are required if there are regular simultaneous demands for hot water, i.e. multiple bathrooms.

Combi boilers save space because:

- They are fed directly from the water main, with no need for a hot water storage cylinder or cold water feed cistern.
- They are usually intended for use in a sealed system which does not require a feed-and-expansion cistern (allows a dry roof space).

Before selecting a combi boiler, check the manufacturers' instructions to ensure that the dwelling has both satisfactory water pressure and an adequately-sized water supply pipe. Otherwise, hot water service may not be adequate.

Boiler types

Space heating

The power (rate of heat output) of combi boilers is usually governed by hot water service requirements, and often exceeds that needed for space heating. Consequently most combi boilers are designed with modulating burners; i.e. they reduce the firing rate to match the lower heat output requirements for space heating. In some cases the boiler design heat output for space heating is lower than that for domestic hot water.

Hot water

Factors to consider are:

- The time taken for hot water to reach an acceptable temperature.
- Hot water flow rate at the acceptable temperature.
- How long this rate can be sustained.
- Can hot water be drawn off at more than one point simultaneously?

These factors will be influenced by the following:

- The size of the internal hot water store. A store can reduce the delay in delivering hot water. There are four different types:
 - Instantaneous: no internal hot water store.
 - Keep-hot: small or no internal hot water store, keeps water within the boiler permanently hot to reduce warm-up time at boiler start-up (sometimes called 'warm-start').
 - Medium store: sufficient to meet small hot water requirements without delay, but insufficient for a bath.
 - Large store: sufficient for a bath or multiple simultaneous draw-off without delay.
 - Combined Primary Storage Units (CPSU): see figure 5.
- Boiler power affects the rate at which hot water at the required temperature can be drawn off after any internal store is exhausted.
- Boilers generally limit the hot water flow rate to ensure the declared temperature rise.

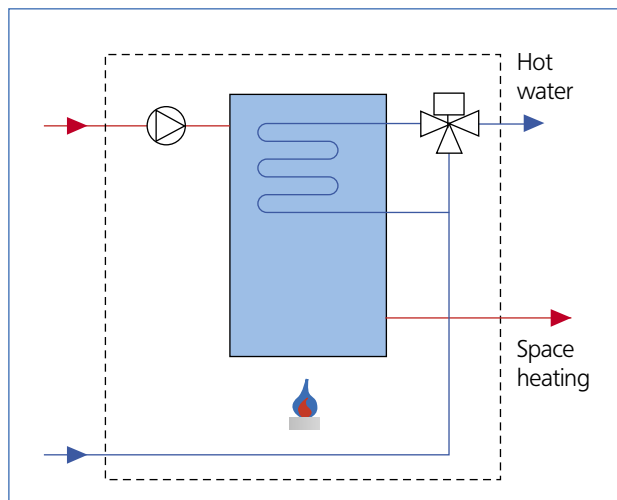


Figure 5: CPSU

Combined primary storage units

CPSUs are a special category of storage combi boiler. They include a very large store of water (a minimum of 70 litres) designed to buffer both the hot water and space heating requirements. The store is sufficiently large to reduce frequent boiler cycling. CPSUs allow radiators to warm up very quickly and are capable of providing hot tap water at a high flow rate.

3.4 Range Cooker boilers

Some gas-fired cookers have a hot water boiler (either integral or separate).

The latest units have two burners: one is for heating and hot water; the other is for cooking and has independent control. The casings of these cooker boilers have relatively high heat loss, which can be useful in winter but not in summer. Condensing units are now being introduced.

4. Systems and components

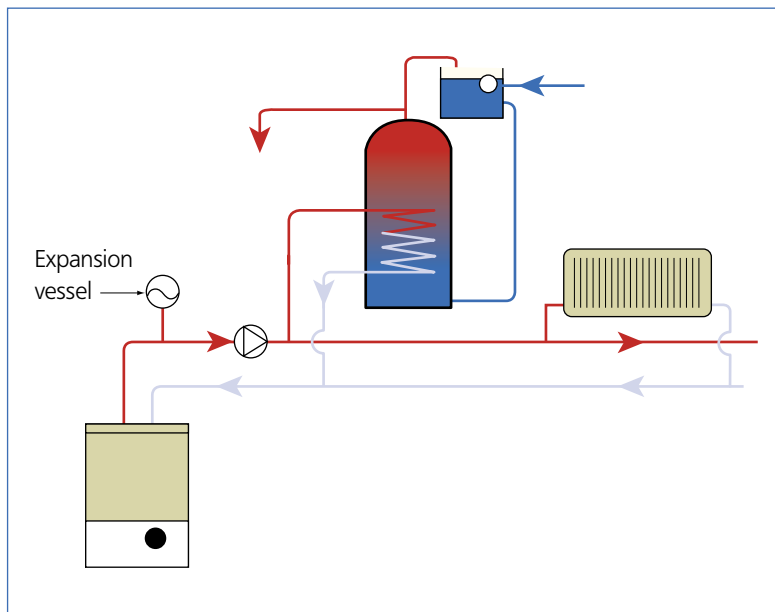


Figure 6: Sealed system

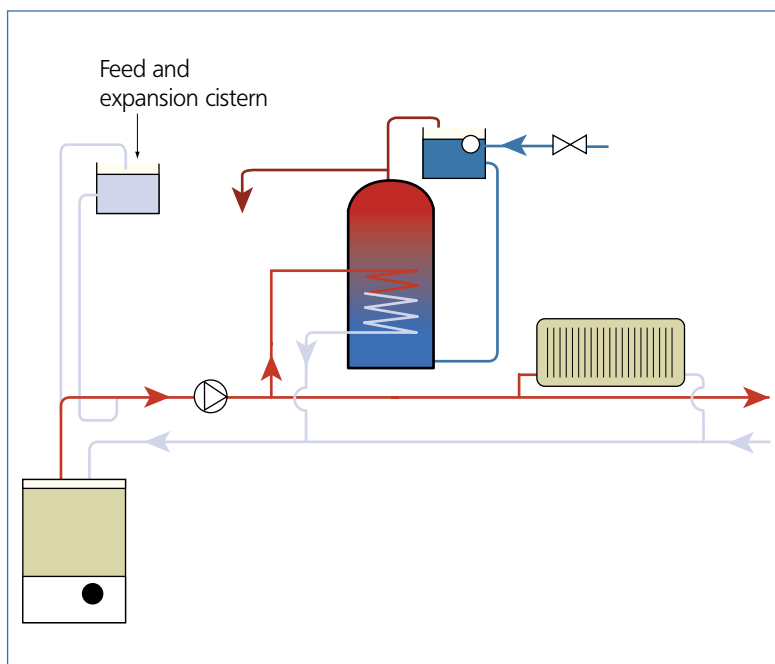


Figure 7: Open system

Systems may either be sealed or open-vented to prevent ingress or escape of air. In the past, most installations were open-vented, but many are now being replaced by sealed systems. Whether a system is sealed or open vented makes no difference to its energy efficiency.

4.1 Sealed and open-vented systems

Sealed

This is a popular option for new systems and increasingly used for boiler replacements. The feed-and-expansion cistern is replaced by an expansion vessel incorporating a diaphragm to accommodate variations in water volume. As the system is not open to the atmosphere, the pressure rises with increasing temperature, and additional safety controls must be installed (these are often within the boiler). The system will need a relief valve connected to an external discharge point, which must be placed where any discharge of hot water will be harmless. There is no permanent connection to a water supply, and the system may have to be topped up with water occasionally.

As the system is not open to the atmosphere, there is little possibility of oxygen being absorbed into the water and, consequently, reduced risk of corrosion. Because these systems may remove the need to install pipes and cisterns in the roof space, they reduce the risk of freezing.

Most combi boilers, and all system boilers, are designed for use with sealed systems and will usually incorporate system components, including a pump, expansion vessel and safety controls within the boiler case. In such cases, it must be ensured that this integral expansion vessel has sufficient capacity to allow for the water expansion of the whole system.

Open-vented

The majority of existing systems with a regular boiler and an indirect hot water cylinder are open vented. 'Open vent' refers to the separate vent pipe which is open to the atmosphere. The system also needs a feed-and-expansion cistern to allow for changes in water volume with temperature. This cistern has to be at the highest point of the system, usually in the loft space where it must be protected against freezing.

Systems and components

4.2 Domestic hot water

The main issues to be considered regarding domestic hot water are:

- The number of people in the dwelling.
- The number of baths/showers/taps.
- The hot water flow rate required.
- Likelihood of simultaneous hot water draw-offs.
- Availability of space for a hot water cylinder, or storage-combi, or CPSU.
- Importance of a dry loft.
- Feasibility of solar water heating.

Specific issues relating to combis are given in Section 3.3.

Most existing regular boiler systems employ a vented, indirect, hot water storage cylinder. In households with a single bathroom, these are typically of 117-140 litre capacity, but for larger dwellings with more than one bathroom (and perhaps with separate shower facilities), a larger cylinder capacity will be required⁽³¹⁾.

High performance cylinders contain a rapid heating coil. This is a heat exchanger with larger surface than normal, which reduces the time taken to heat the water and may reduce boiler cycling. It gives a valuable reduction in recovery time between large draw-offs (such as baths), and helps to increase system efficiency (especially with older boilers). High performance cylinders often have improved factory-applied insulation as well.

Unvented cylinders are increasingly used in new systems and these operate at mains pressure. They employ an internal expansion facility or a dedicated external expansion vessel, and do not require a feed cistern in the loft.

Most hot water cylinders and thermal stores are supplied with factory-applied insulation and these should always be used in preference to cylinders with separate jackets. Cylinders should satisfy British Standards with regard to insulation and heat exchanger performance.

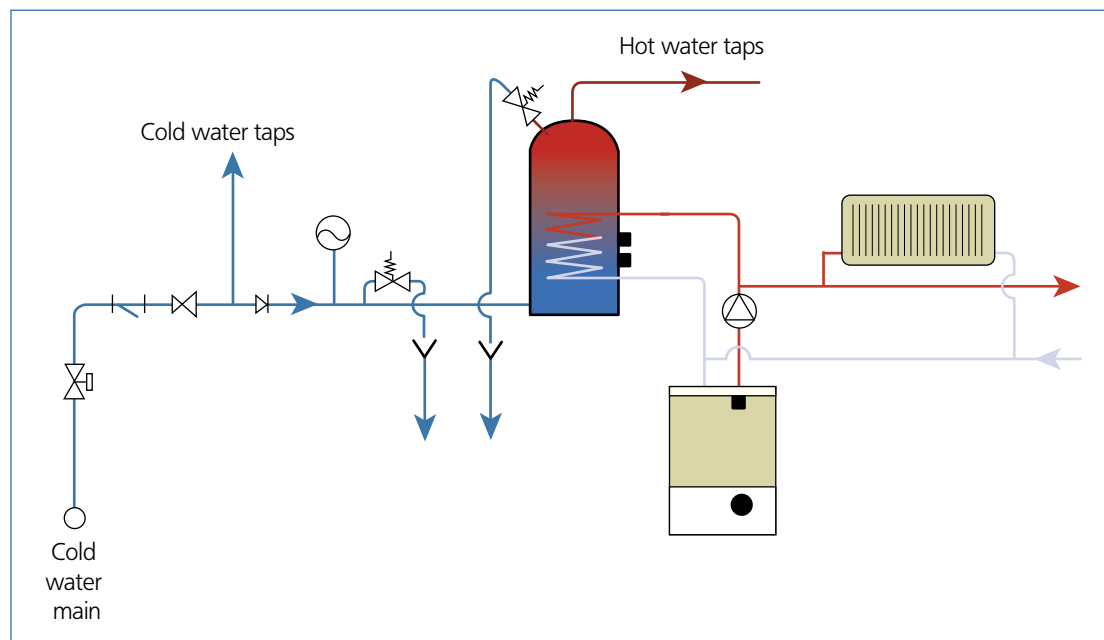


Figure 8: Unvented hot water system

Systems and components

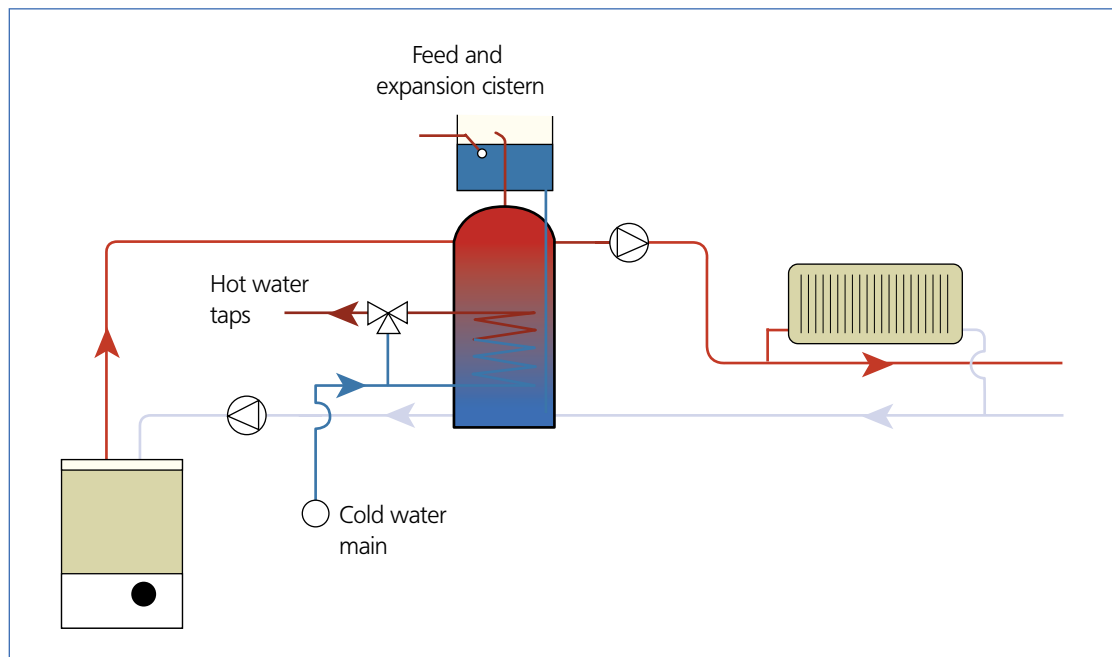


Figure 9: Thermal storage system

Medium-duty cylinders have inferior performance and do not meet CHeSS basic requirements or those of the building regulations, and so should not be used for either new or replacement installations.

Thermal stores can be obtained that hold water at high temperatures, heated by the boiler directly. These are available for 'hot water only' or 'hot water and space heating'.

Mains-fed systems such as combi boilers, unvented cylinders and thermal stores can supply hot water at mains pressure. This is extremely beneficial when high pressure is needed at the outlet, e.g. for showers. It is therefore important to ensure that the incoming water supply pressure and flow to the dwelling are adequate and that all showers have the hot and cold water supply at the same nominal pressure. This eliminates the need for a shower pump.

Table 2: Domestic hot water flow rates

System type	Flow rate		
	Low	Medium	High
Instantaneous combi ^{1,3}	x	x	x
Storage combi ^{2,3}	x	x	
Thermal store ³		x	x
Unvented storage ^{2,3}		x	x
Vented storage ⁴		x	x

Notes

1. Depends on boiler heat output; less satisfactory for two or more simultaneous draw-offs unless very high heat input
2. Depends on boiler heat output and storage capacity
3. Depends on adequate mains water supply
4. Requires high level feed cistern

Systems and components

4.3 Solar hot water systems

The use of solar water heating provides the opportunity to reduce running costs and carbon emissions when used in conjunction with wet central heating systems. There is now a large choice of systems available and the technology is improving all the time. Depending on system design a thermal solar system can provide most of the average dwelling domestic hot water requirement in the summer and up 50% all the year round.

There are a range of different systems available, but the general principle is that roof-mounted solar collectors are heated by the sun, and the heated water is passed to a special hot water storage cylinder. This water is then further heated to raise the temperature, if necessary, by the gas-fired boiler system.

Figure 10 shows a typical open vented system with a large cylinder containing an additional solar heat exchanger, usually referred to as twin-coil. Sealed solar primary systems (i.e. to collectors) are commonly used and unvented 'twin-coil' cylinders are also available. The capital costs of systems are relatively

high but costs can be recouped through reduced heating bills. When systems are being upgraded and the hot water cylinder is being replaced, consideration should be given to installing a larger cylinder containing a solar heating coil. This facility will then save cost and disruption if it is decided to install solar heating panels at a later date.

Solar hot water systems can also be used in conjunction with some combi boilers. However, this should only be considered where the combi boiler is part of an integrated solar package since systems based on ad-hoc components may not achieve good energy savings and boilers may not operate correctly. When considering this option the boiler manufacturer's advice should always be obtained.

Separate guidance and advice on solar systems should be sought^(34,46). Also where appropriate, low carbon supplementary heat sources such as heat pumps or wood burning stoves can be considered. Where these are combined with gas-fired systems, expert advice should be sought to ensure both safety and energy efficiency is optimised.

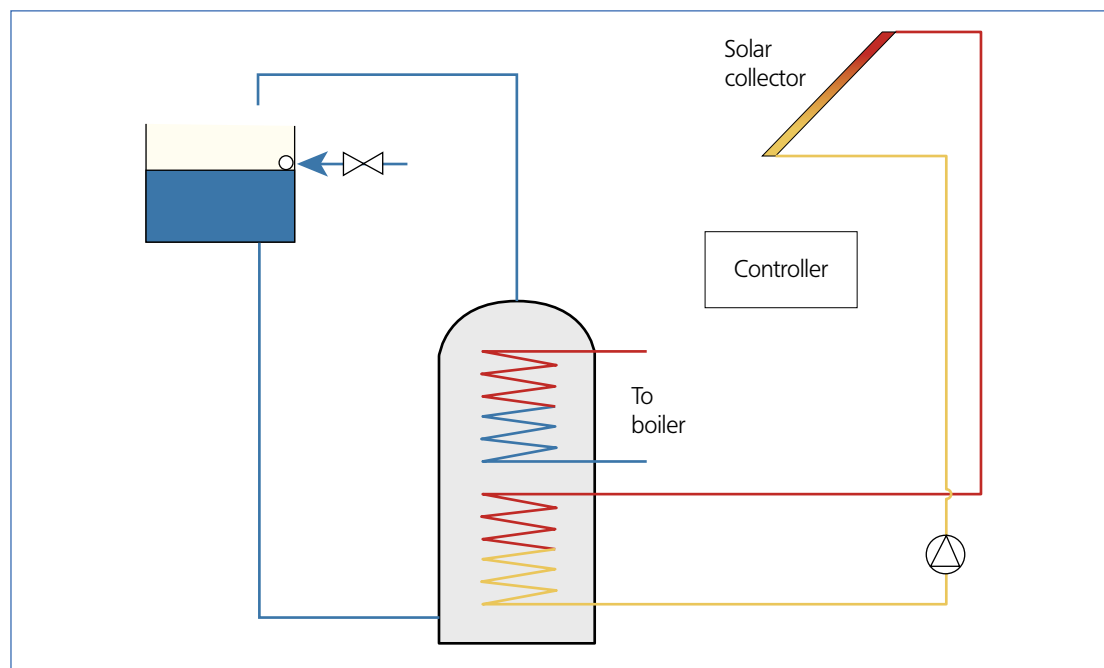


Figure 10: Solar water heating system for connection to a boiler (safety controls not shown)

Systems and components

4.4 Passive Flue-Gas Heat Recovery Devices (PFGHRD)

A class of energy saving devices is now available for use with certain condensing combi boilers (see figure 11). The passive flue gas heat recovery device (PFGHRD) uses a heat exchanger and heat store fitted into the flue of a boiler to pre-heat domestic hot water supply.

The cold inlet water is warmed directly from the flue gases, and also indirectly from energy in the heat store, whenever the boiler operates for space heating or hot water service. The unit can also save water, because it reduces the time during which water delivered from an instantaneous combi is rejected before it reaches an acceptable temperature.

Annual savings depend on the demand for both space heating and water heating within the building. Named products can be recognised for their energy saving in SAP2005 assessments (using Appendix Q). Note that these devices can only be used with boilers specifically designed and approved to use them.

4.5 Upgrading systems

Many existing wet central heating systems are poorly controlled and of obsolete design. Poor design features which fail to meet current building regulations and best practice requirements include:

- Gravity circulation to the hot water cylinder, which results in stored water being slow to re-heat.
- Lack of cylinder thermostat, resulting in excessive stored water temperature (risk of scalding).
- Lack of room thermostat (rooms are too hot).
- Lack of TRVs, causing excessive room temperatures and poor system balancing.
- Absence of boiler interlock, causing the boiler to stay hot and to cycle unnecessarily during programmed periods.

It is important that an existing system is cleaned and recommendations regarding the use of corrosion inhibitor are followed when boilers are replaced and/or systems upgraded⁽⁵⁷⁾. When upgrading, use the CHeSS specifications (see Section 6).

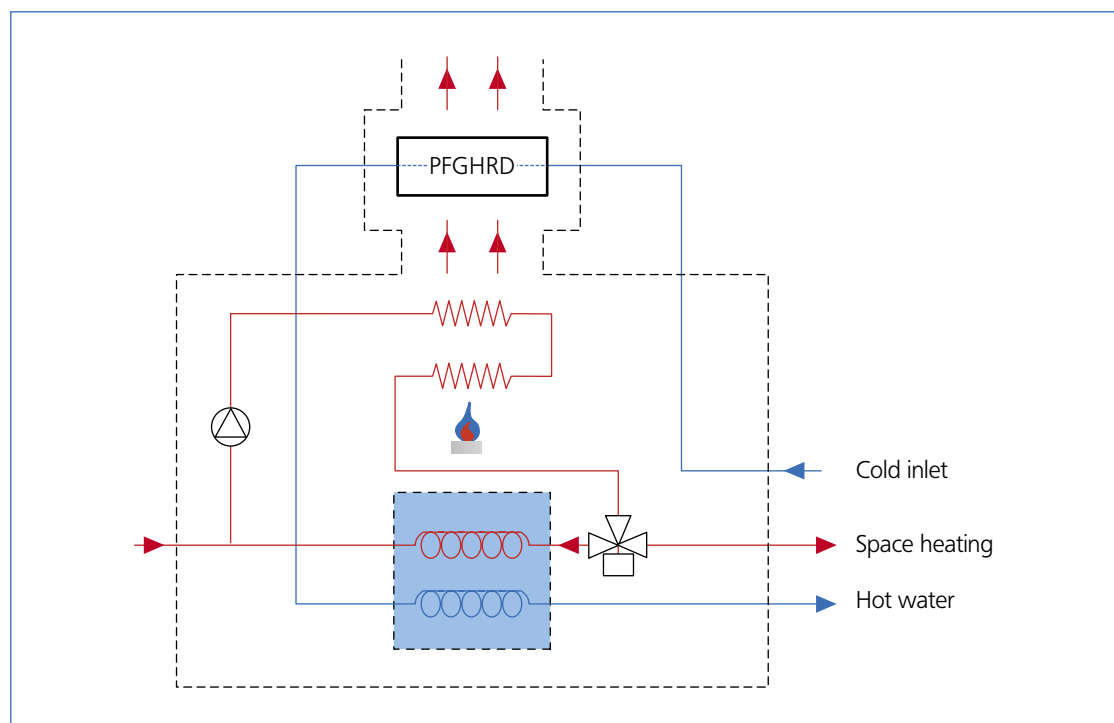


Figure 11: PFGHRD fitted to instantaneous combi boiler

Systems and components

4.6 Flue types

Most new boilers installed will be of the condensing type and in most cases they will be replacing non-condensing units. The different flue arrangements of the existing model may affect the siting of the new boiler. All domestic gas condensing boilers are room-sealed or fanned. Existing non-condensing boiler flues can be open-flue or room sealed, natural draught or fanned (figure 12).

New condensing boilers can have the following flue types, straight-through-the-wall; extended concentric or extended twin pipe (figure 13); or extended non-balanced which is sometimes referred to as a plume management option (figure 14). In addition some flues offer a directional terminal which can be used to minimise plume nuisance. e.g. adjacent to an internal corner (figure 15).

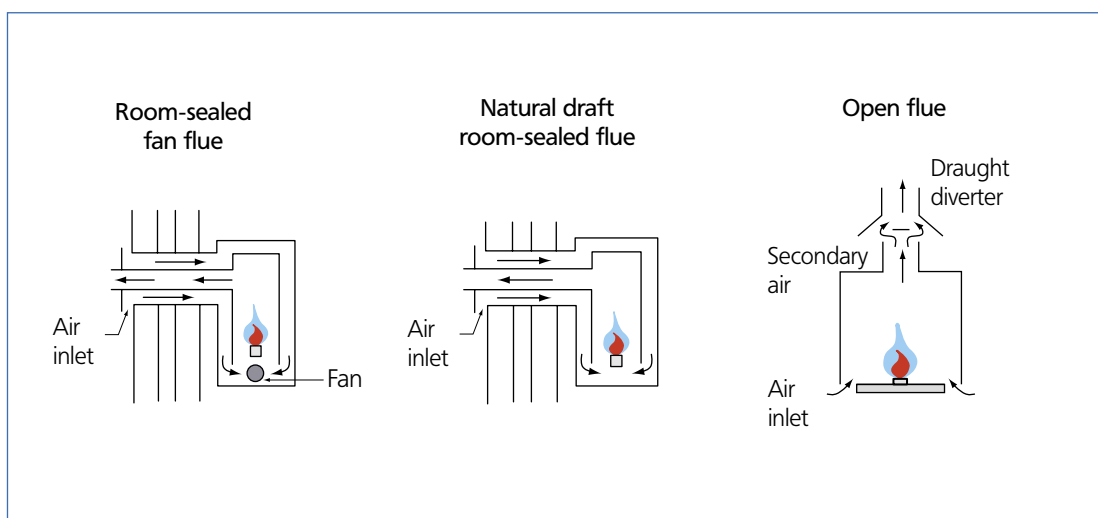


Figure 12: Existing flue types

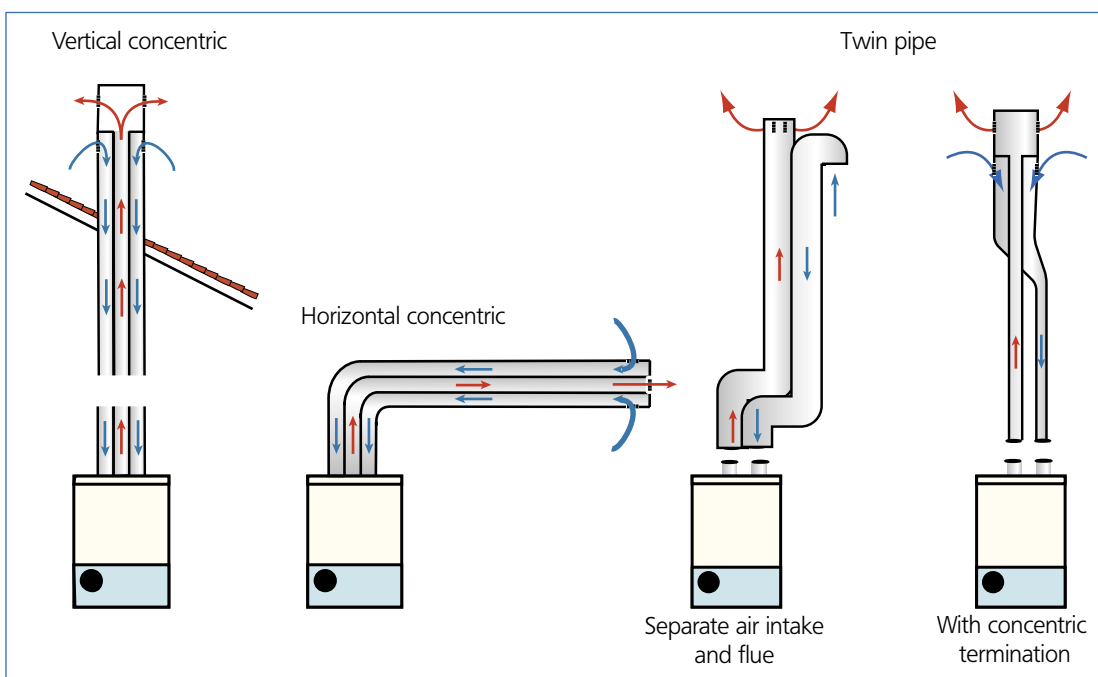


Figure 13: Concentric flues for condensing boilers

Systems and components

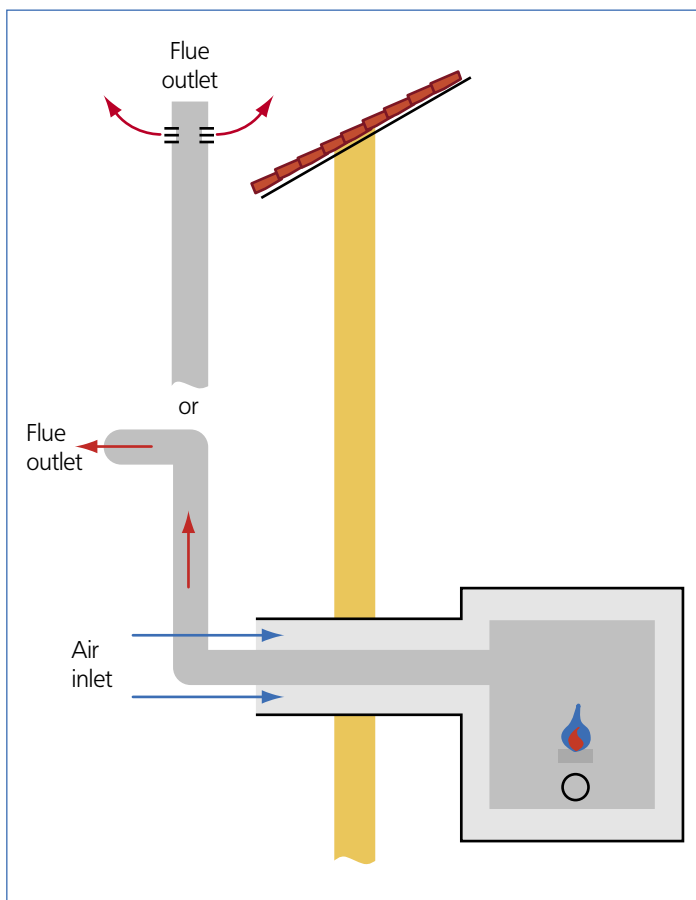


Figure 14: Plume 'management' option

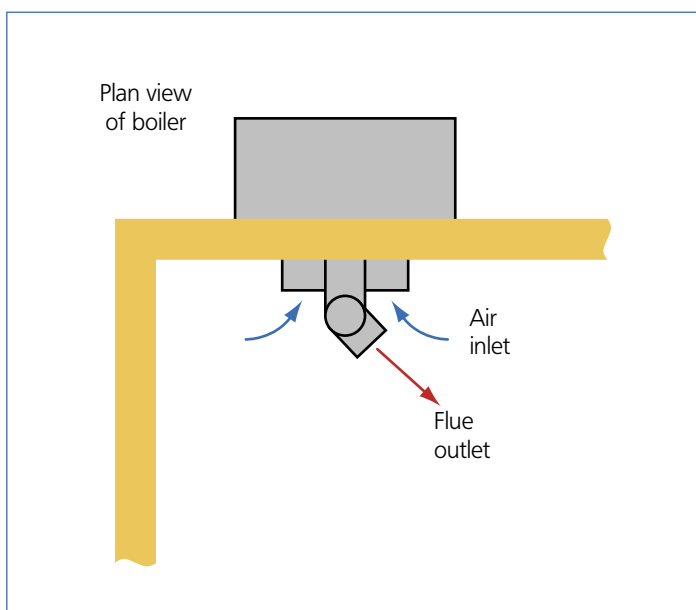


Figure 15: Directional terminal

Important factors to consider when replacing a non-condensing boiler with a condensing unit.

- New gas-fired boilers are very efficient and operate with comparatively low flue-gas temperatures.
- Room-sealed appliances must use flue systems which are certificated and supplied as part of the boiler or specified by the boiler manufacturer⁽³³⁾. Always refer to the boiler manufacturers instructions to check what options can be used.
- The plume will be visible for much of the time the boiler is in use and can sometimes cause a nuisance. For this reason, special consideration should be given to the siting of the new flue terminal (see Section 9.2).
- A wide range of extended flues are now available which can be used to minimize the possible nuisance caused from the flue products.
- Extended and vertical flues are available for many condensing boilers in concentric and twin-flue configurations. In some cases these allow flue lengths of over 30m, with a number of bends.
- A non-balanced flue, where the air intake and flue outlet are run to separate locations, is available for use with some boilers. Here the air intake can remain at low level but the flue outlet can be directed to high level. This is sometimes referred to as the plume management option and can often reduce plume nuisance in restricted locations.
- Directional flue terminals, where the direction of the flue stream can be adjusted, are also available for use with some boilers.
- Room-sealed boilers do not require special provision for combustion air in that room.

Systems and components

4.7 Heat emitters

A wide range of heat emitters are available (see table 3). Radiators remain the most popular type and modern versions are usually slightly smaller for an equivalent heat output. Many modern radiators also have lower water content, making for a faster warm-up.

The heat output of the radiators should be carefully calculated^(31,35). All radiators should be fitted with a TRV (see CHeSS) excluding those in a room with a controlling room thermostat.

Underfloor heating is an attractive alternative in the right circumstances, but it needs to be installed by specialists⁽³⁶⁾. It also requires careful control in accordance with the manufacturer's guidance.

Other important points regarding heat emitters include the following.

- Radiators sited under windows counteract cold draughts and so give a more comfortable environment in the room.
- Radiators should be installed close to the floor, preferably 100-150mm above finished floor level.
- Wide, low radiators will be more effective at heating the room evenly than tall, narrow designer styles.
- Enclosures around radiators reduce the heat output.

4.8 Circulator pumps

A circulator pump must be selected with sufficient design pressure and flow rate for the total system resistance when operational. If the pump is undersized or is set too low, the flow may be inadequate to meet the manufacturer's minimum requirement. This will result in the boiler operating with a larger temperature rise than intended. On the other hand, a pump that is larger than required will result in excessive water velocity noise as well as unnecessary electricity consumption.

Circulator pumps are built into combi and system boilers and it must be ensured that the pump has adequate head and flow rate to meet the system design.

Pumps that are installed separately (i.e. not supplied as part of the boiler unit) and that have automatic speed control should only be used in heating systems with TRVs if the design of the pump and system ensures that the minimum flow rate through the boiler (as specified by the boiler manufacturer) is certain to be maintained under all conditions.

Multiple pumps (one for each water circuit) may be used as an alternative to a single pump with motorised valves, provided that each water circuit has a non-return valve. Advice on pump sizing can be obtained from the British Pump Manufacturers' Association (BPMA) website at www.bpma.org.uk

Table 3: Heat emitters

Type	Comment
Panel radiator	The most common type in modern housing. Available in a wide range of outputs and sizes.
Compact radiator	A radiator or convector fitted with top grille and side covers.
Column and designer radiators	Available in a wide range of colours and shapes.
Low Surface Temperature (LST) radiator	Safe option where young children or the elderly may be at risk. Limited to a surface temperature of 43°C in order to prevent injury.
Towel rail	For towel warming and will give some heat to the bathroom.
Fan convector	Wall hung and kickspace units available. These provide a more rapid heating response. They need an electrical supply and there may be some fan noise.
Underfloor heating coils	Requires specialist installation and controls. May be less suitable for rooms requiring only intermittent heating.

5. Controls

Installing effective controls can have a major impact on the energy consumption of heating and hot water systems. This section describes the types of controls now available and outlines which are most suitable for different heating systems.

Effective controls will increase operating efficiencies, especially when older systems are being updated. They also provide the householder with the opportunity to minimise energy consumption by ensuring the right comfort temperatures are maintained and so reducing overheating. Reducing room temperatures will also save energy (see box). Timed space and water heating periods will also help to avoid excessive use of energy. Heating fuel is expensive (gas-fired boilers typically consume 30-70 pence of fuel an hour when operating) and reducing the firing time will make a proportionate difference to running costs.

A good control system is one which ensures the boiler does not operate unless there is a demand and that only provides heat where and when it is needed in order to achieve the required temperatures. The selection of suitable controls plays a key part in minimising the overall running costs of a heating or hot water system.

Control standards must meet best practice to maximise the efficiency of a heating system. However, in order just to achieve the SEDBUK efficiency claimed for a boiler, at least the basic set of controls given in CHES must be installed (see Section 6).

The cost benefit of controls should not be underestimated. Upgrading the controls on older heating systems can save up to 18% on energy bills, for example when a full set of controls is fitted to a system which previously had none. This is important, as over 80% of the energy a householder uses in the home is for space and hot water heating.

VAT on heating controls

Heating controls for domestic wet central heating systems are recognized by the Government as an energy efficiency measure. VAT is therefore charged at a lower rate – currently 5% instead of the full rate of 17.5%. This lower rate applies to both equipment and installation costs, but only when the work is carried out by an installer registered for VAT.

Energy savings from good controls

- Installing a minimum standard of controls on a system which previously had none can reduce fuel consumption and CO₂ emissions by 18%.
- Reducing higher than necessary room temperatures will cut energy use. Turning down the room thermostat by 1°C will reduce space heating consumption by 6-10%.
- An easy to use programmer that is adjusted to match the householder's occupancy pattern helps reduce wasteful heating when no one is at home.

5.1 Individual controls

This section describes the range of controls commonly used in gas-fired systems, what they do and why they are important.

The controls listed here are normally installed separately from the boiler although some may be incorporated within it. For clarity of specification, Appendix C contains a full list of controls including those often fitted within appliances and gives industry-agreed definitions. Appendix E provides simple explanations that can be given to householders on what controls do and how they should be used.

Further advice on controls most suitable for the disabled, particularly with visual and dexterity impairment, can be found in the Ricability report⁽³⁷⁾.

In the following listing, best practice controls are noted.

Time Switch

A simple time control that will only switch one circuit. It should be chosen so that it is easy to understand and reset, especially when there is a change to the householder's domestic routine.

Programmer

This can switch two circuits separately (usually heating and hot water). There are two basic types:

- A standard programmer uses the same time settings for space heating and hot water.
- A full programmer allows fully independent time setting for space and hot water heating.

Controls

Room thermostat

A simple room temperature control. Traditional types use expansion/contraction (e.g. bimetallic strip) to operate a switch or relay. They usually include an accelerator or anticipator, which is a small resistance heater having the effect of smoothing out the temperature cycle by preventing overshoot.

Electronic room thermostats are also available which can react more rapidly to temperature change. Some of the latest units include a function to control the boiler firing frequency. These units are designed to minimise the variations in both the boiler and room temperature.

Wireless units that provide increased flexibility in positioning and eliminate visible wiring are now commonly used.

Programmable room thermostat (best practice)

This allows different temperatures to be set for different periods of the day or week and so can provide a good match to householder living patterns, particularly if occupancy varies. This device also has a 'night setback' feature where a minimum temperature can be maintained. Many of these models are battery-operated and can replace a conventional thermostat without the need for additional cabling. Some versions also allow time control of hot water provision. Electronic and wireless versions with extra functions are available.

Cylinder thermostat (best practice)

A simple control of stored hot water temperature, usually strapped to the side of the hot water cylinder. It is commonly used with a motorised valve to provide close control of water temperature and boiler interlock.

Frost thermostat

A simple override control used to prevent frost damage to the dwelling and/or boiler system. The frost air thermostat should be fitted in a suitable place within the dwelling to ensure a minimum temperature is always maintained.

Pipe thermostat

Where the boiler is installed in an unheated area such as a garage, a pipe thermostat should be fitted to the exposed pipework. This is in addition to the frost air thermostat and is designed to prevent the boiler from firing unnecessarily in cold weather and so wasting fuel. If the boiler incorporates its own frost thermostat, a separate pipe thermostat is normally not required.

Thermostatic radiator valve (TRV) (best practice)

TRVs are used to limit the temperature in individual rooms. They also prevent overheating from solar and other incidental gains. In this way, they cut down on unnecessary consumption. Programmable units, which can be timed to switch on and off, are also available.

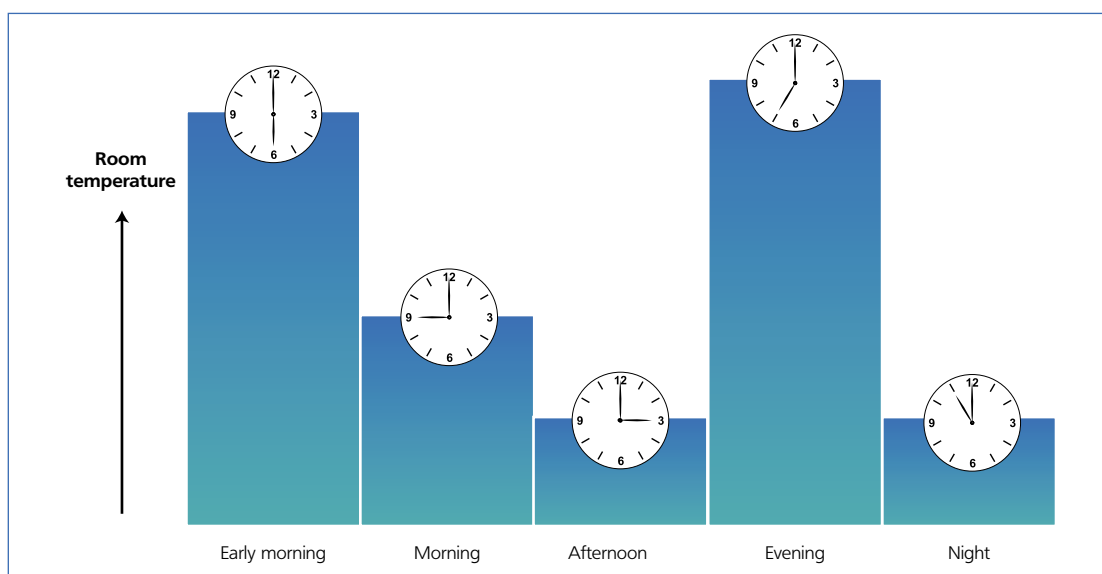


Figure 16: A programmable room thermostat offers greater flexibility in setting temperatures and times than a standard room thermostat, producing greater savings

Controls

Thermostatic hot water temperature limit valve

These self-acting valves without motors are used to limit hot water temperature in domestic hot water cylinders. Some units sense primary water (boiler) temperature, others have a separate remote sensor for stored water temperature. Cylinder controls should not be used with these unless they also operate an electrical switch to provide boiler interlock. Otherwise the boiler will cycle unnecessarily.

Motorised valve (best practice)

These control water flow from the boiler to heating and hot water circuits. Two-port valves can also be used to provide zone control e.g. allowing lower temperatures to be set for sleeping areas or different heating times. An explanation of the different types is given in Appendix D. Multiple pumps are an alternative to motorised valves (see Section 4.8).

Boiler interlock (best practice)

This is not a device, but rather a wiring arrangement to prevent the boiler firing when there is no demand for heat. The boiler is interlocked when it is switched on and off by thermostats containing electrical switches. All thermostats in the heating system fitted with electrical switches should be wired in this way. This includes room thermostats, programmable room thermostats, cylinder thermostats and some types of boiler energy managers. In many cases, the interlock is also applied to the operation of the pump, although any requirements for pump overrun stipulated by the boiler manufacturer must be observed. Without interlock, a boiler is likely to cycle on and off regularly, wasting energy by keeping hot unnecessarily.

Achieving interlock depends upon the boiler type and the controls fitted. Typical examples of boiler interlock are as follows.

- Regular boiler with one 3-port or at least two 2-port motorised valves. The interlock is usually arranged so that the room or cylinder thermostat switches the power supply to the boiler (and sometimes the pump) through the motorised valve end switches. In other words, electrical power from the programmable room thermostat (or separate programmer and room thermostat) and the cylinder thermostat will drive the valve motor to the open position. Once the motor is fully open, the end switch will close and electrical power is then passed to the boiler and pump. Once the power to the

valve is removed (programmer off-period, or thermostat is satisfied) the motorised valve will close, the end switch will open and the boiler and pump will stop.

- Regular boiler with two separate pumps for heating and hot water. Where separate pumps are used, advice from the manufacturer is needed in regard to the correct use of relays, check valves, etc.
- Combi boiler. This only requires a time switch and room thermostat (or programmable room thermostat) connection to provide interlock as hot water delivery is controlled directly by the boiler. A boiler energy manager may need a different wiring arrangement, achieving interlock by an alternative method.

Automatic bypass valve (best practice)

This controls water flow according to the differential pressure of the water across it. It is used to maintain a minimum flow rate through the boiler and to limit the circulation pressure when alternative water paths are closed. A bypass circuit must be installed if the boiler manufacturer requires one, or specifies that a minimum flow rate has to be maintained while the boiler is firing. The installed bypass circuit must then include an automatic bypass valve, not a manual (fixed position) valve.

The use of an automatic bypass is important where the system includes a large number of TRVs. When most of these are open, the automatic bypass remains closed, allowing the full water flow to circulate around the heating system. As the TRVs start to close, the automatic bypass starts to open, maintaining the appropriate water flow through the boiler. It also helps to reduce noise in the system caused by excess water velocity.

An automatic bypass is always preferable to a fixed bypass. With a fixed bypass, there is a constant flow of hot water coming out of the boiler, which is fed directly into the return at all times. This means that the boiler operates at a higher temperature, reducing efficiency and restricting the amount of heat transferred to the system.

It is very important that both automatic and fixed bypasses are correctly adjusted. Poor adjustment will give rise to increased boiler return temperatures and reduced boiler efficiency.

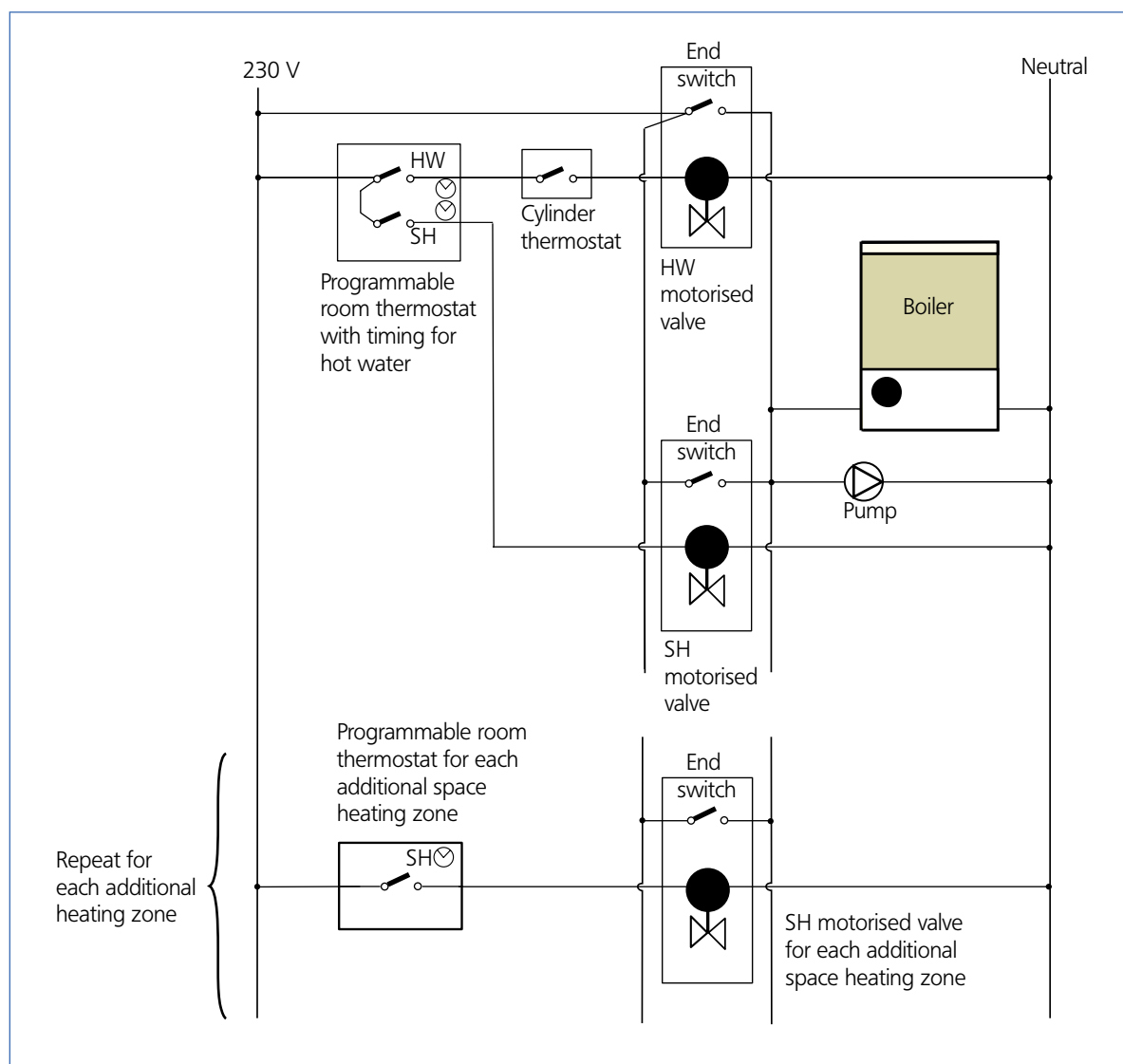


Figure 17: Boiler interlock in a system with two, 2-port valves (this shows the general logic and should not be interpreted as an installation instruction, as the actual wiring will depend on the particular products used).

Particular care is required when selecting a pump with automatic speed control for a system with an automatic bypass. It is important to ensure that the boiler manufacturer's minimum recommended water flow rate is maintained under all operating conditions.

Boiler energy manager

These are self-contained devices which have a number of the functions found in other individual controls described in this section. They usually have a number of control functions including weather or load compensation and sometimes optimum start,

Wireless controls

Wireless controls should be designed with adequate immunity to blocking by other radio transmissions. If not, they may become unreliable or cease to work as nearby radio frequency bands become increasingly used for mobile phones and other communication services. See CHSS Note 12 in Appendix A for more details on wireless controls.

frost protection, night setback, anti-cycling control and hot water override. Table 4 lists a range of control functions which may be included.

Table 4: Control functions commonly built into boilers and control units

Compensator	Reduces boiler water temperature for space heating according to internal/external air temperature. It should increase the efficiency of condensing boilers by reducing the average water temperature of the system.
Delayed start	Reduces energy use by delaying the heating start time to after the programmed time when the weather is mild.
Night setback	Allows a low temperature to be maintained at night, providing improved comfort and reduced warm-up time in the dwelling in cold weather. In this way it can reduce the risk of hypothermia. A programmable room thermostat can fulfil this function.
PI or PID	The letters stand for Proportional/Integral, or Proportional/Integral/Derivative. These control functions can be built into room thermostats to reduce variations in room temperature.
Anti-cycling control	Delays boiler firing in order to reduce cycling frequency, but is unlikely to produce significant energy savings. In some circumstances consumption may be reduced, but normally at the expense of performance or comfort. Standalone units (i.e. those not supplied as part of the boiler) are not generally recommended as they provide little or no improvement over the basic level of control detailed in CHeSS.

Key for figures 18 to 20

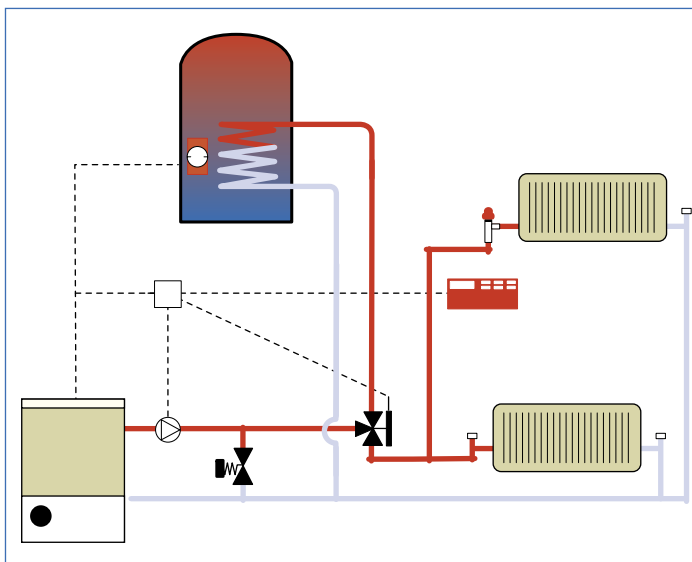
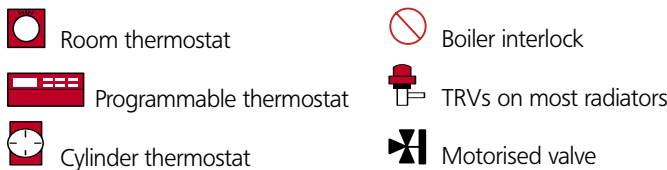


Figure 18: Best practice schematic for regular boiler systems (the programmable room thermostat must have an additional hot water timing capability)

5.2 Selecting controls

The minimum sets of controls consistent with building regulation requirements and satisfactory heating system performance are those listed as basic in the CHeSS specification (see Section 6). However, it is recommended that the best practice level is followed. Figures 18 and 19 show best practice regular and combi boiler systems.

Best practice – regular boilers

- Programmable room thermostat with additional hot water timing capability.
- Cylinder thermostat.
- TRVs on all radiators except in rooms with a room thermostat.
- Automatic bypass valve.
- Boiler interlock.

Best practice – combi boilers

- Programmable room thermostat.
- TRVs on all radiators except in rooms with a room thermostat.
- Automatic bypass valve.
- Boiler interlock.

New systems must always be fully pumped and existing semi-gravity systems (i.e. with gravity circulation to the hot water cylinder) should be converted. Published boiler efficiencies cannot be achieved unless the whole system is fully pumped and effectively controlled.

Controls

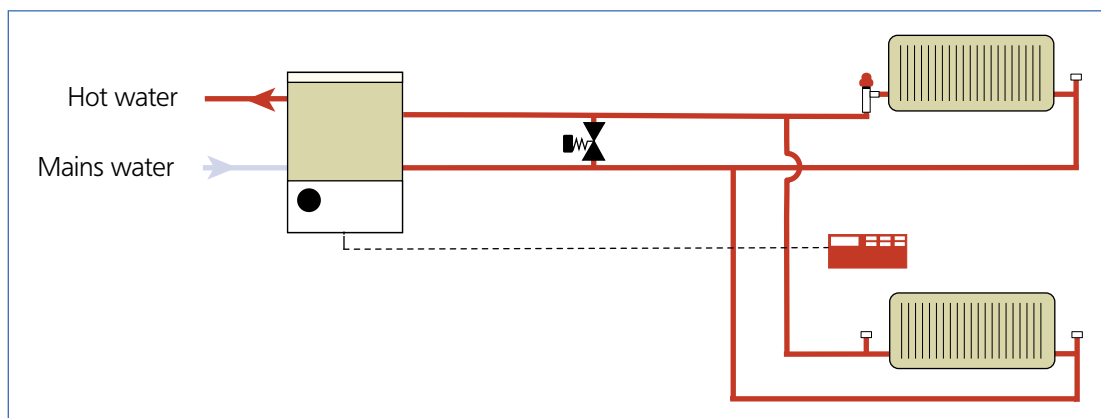


Figure 19: Best Practice schematic for combi systems

5.3 Further control improvements

Zone control

CHeSS best practice and basic options already include zone temperature control, achieved using TRVs. If zones are to be independently time controlled as well, it will usually be necessary to install additional room thermostats and a two-port motorised valve (to allow the programmer to shut off water circulation). The wiring in such situations must be arranged so that boiler interlock works in all zones.

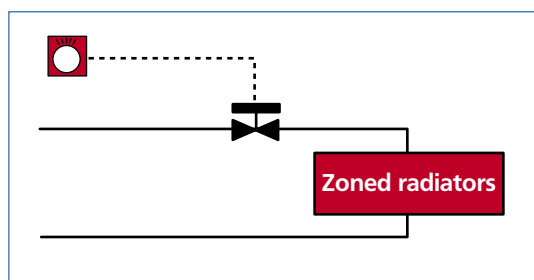


Figure 20: Zone controls

Zone control is particularly beneficial in larger, poorly insulated buildings. Building regulations in the UK require that no zone is larger than 150m² in floor area and each zone should be capable of independent time and temperature control.

Systems that provide multiple zone control are now available which allow time and temperature control of individual rooms or multiple zones, thereby providing more effective and efficient heat distribution in the dwelling. Individual time and temperature control of separate rooms can be achieved using TRVs fitted with special heads which include on-off control linked to a programmer (either wired or wireless).

Weather compensation

As external temperatures rise, so a weather compensating function reduces average water circulation temperature (see figure 21). Greatest benefit is achieved with condensing boilers.

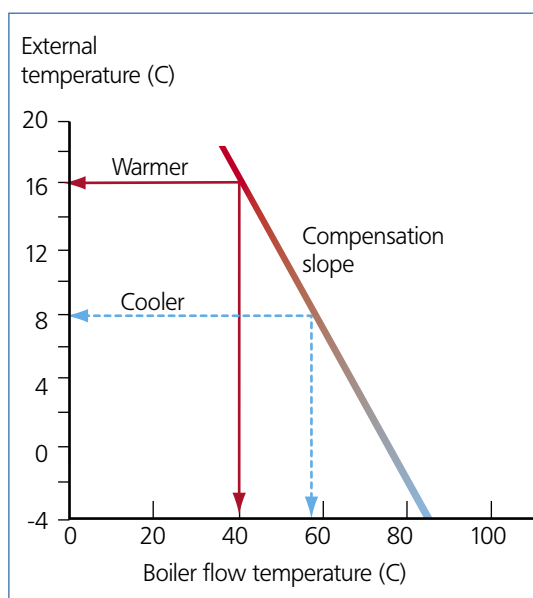


Figure 21: Weather compensation

Controls

Delayed start

The user sets the timer to bring on the heating taking account of the time it normally takes to heat the dwelling to an acceptable temperature under cold ambient conditions. A delayed start unit, will, at the time of switch-on of the programmer/room thermostat, compare the current room temperature to that required and will then hold off the heating if appropriate. Therefore during mild weather, as heat-up times are reduced, energy can be saved. (See figure 22). Room thermostats with a delayed start function are now available.

Optimum start

The user sets the occupancy time and the required room temperature and the control then calculates the required pre-heat time. The approach is to always reach the required room temperature in the optimum time independently of outside temperature. With optimum start controls the priority is ensuring comfort whereas with delayed start controls the priority is energy saving.

Integrated boiler and system controls

Control options are increasingly being offered by both boiler and control manufacturers to provide integrated control strategies. For example systems are available which allow boiler flow temperature to be closely controlled by an outside (weather) or inside compensator. This is achieved by adjusting the firing rate of the boiler.

Room thermostats are also available that modulate the heat output of the boiler in response to the gap between the measured and target room temperature. This type of control has the potential to reduce the boiler return temperature and so increase the efficiency of a condensing boiler and reduce temperature swing (above and below the target air temperature) without excessive boiler cycling. Some of the thermostats and boiler combinations that use this strategy conform to 'Open Therm' which is an independent protocol/specification for signalling between separate components of a heating system.

Home automation

Whole house control systems are now available, integrating the operation and control of a wide range of systems and appliances. Of particular relevance for energy efficiency is:

- Time and temperature control of individual rooms.
- Features to permit remote setting and operation of time switches, i.e. programmers and thermostats.
- Feedback for the householder on energy use, which can encourage energy efficiency.

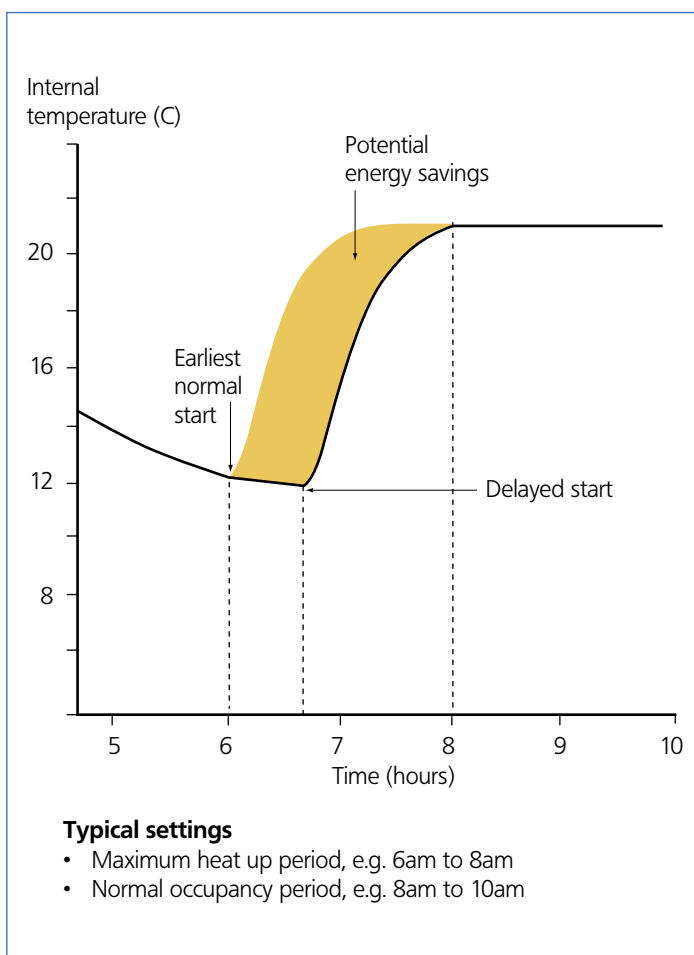


Figure 22: Delayed/optimum start function

6. Central Heating System Specifications (CHeSS)

CHeSS provides a series of ready-made specifications for purchasing the components that critically affect the energy efficiency of wet central heating systems. Following them will improve energy efficiency and reduce carbon emissions.

Purchasers should use these specifications to ensure their heating installations will meet best practice or basic requirements. Installers can use them to quote for systems of defined quality, comparable with those of their competitors.

The main elements are reproduced in the following tables and the explanatory notes can be found at the end of this document. The complete specification is available in a separate Energy Efficiency Best Practice in Housing document⁽³⁸⁾. That publication also contains quantified energy, carbon and cost savings for the different specifications.

The basic specifications HR7 and HC7 are sufficient to comply with the building regulations. The two best practice specifications HR8 and HC8 are to be preferred (see table below).

Central heating system specifications (Year 2008)

Basic (2008) (For notes see Appendix A)	
Reference	CHeSS – HR7 (2008)
Description	Domestic wet central heating system with regular boiler (natural gas, LPG, or oil) and separate hot water store.
Boiler (see notes 5 and 6)	<ul style="list-style-type: none"> A regular boiler (not a combi) which has a SEDBUK efficiency of at least 86% (bands A and B).
Hot water store	EITHER <ul style="list-style-type: none"> Hot water cylinder, whose heat exchanger and insulation properties both meet or exceed (see note 7) those of the relevant British Standards (see Refs [7],[8]). OR <ul style="list-style-type: none"> Thermal (primary) storage system, whose insulation properties meet or exceed those specified in Ref [9].
Controls (see notes 10, 11 and 12)	<ul style="list-style-type: none"> Full programmer Room thermostat Cylinder thermostat Boiler interlock (see note 13) TRVs on all radiators, except in rooms with a room thermostat Automatic bypass valve (see note 14)
Installation	See notes 1, 2, 3 and 4.
Basic (2008) (For notes see Appendix A)	
Reference	CHeSS – HC7 (2008)
Description	Domestic wet central heating system with combi or CPSU boiler (natural gas, LPG, or oil).
Boiler (see notes 5 and 6)	<ul style="list-style-type: none"> A combi or CPSU boiler which has a SEDBUK efficiency of at least 86% (bands A and B).
Hot water store	None, unless included within boiler.
Controls (see notes 10, 11 and 12)	<ul style="list-style-type: none"> Time switch Room thermostat Boiler interlock (see note 13) TRVs on all radiators, except in rooms with a room thermostat Automatic bypass valve (see note 14)
Installation	See notes 1, 2, 3 and 4.

Central Heating System Specifications (CHeSS)

Central Heating System Specifications (Year 2008)

Recommended best practice (2008) (For notes see Appendix A)	
Reference	CHeSS – HR8 (2008)
Description	Domestic wet central heating system with regular boiler (natural gas, LPG, or oil) and separate hot water store.
Boiler (see notes 5 and 6)	<ul style="list-style-type: none"> A regular boiler (not a combi) which has a SEDBUK efficiency of at least 90% (band A).
Hot water store	<p>EITHER</p> <ul style="list-style-type: none"> High-performance hot water cylinder (see note 8). <p>OR</p> <ul style="list-style-type: none"> High-performance thermal (primary) storage system (see note 9). <p>In suitable buildings, consideration should be given to fitting a cylinder with an additional heat exchanger to allow for solar water heating.</p>
Controls (see notes 10, 11 and 12)	<ul style="list-style-type: none"> Programmable room thermostat, with additional timing capability for hot water Cylinder thermostat Boiler interlock (see note 13) TRVs on all radiators, except in rooms with a room thermostat Automatic bypass valve (see note 14) <p>More advanced controls, such as weather compensation, may be considered, but at present cannot be confirmed as cost effective.</p>
Installation	See notes 1, 2, 3 and 4.
Recommended best practice (2008) (For notes see Appendix A)	
Reference	CHeSS – HC8 (2008)
Description	Domestic wet central heating system with combi or CPSU boiler (natural gas, LPG, or oil).
Boiler (see notes 5 and 6)	<ul style="list-style-type: none"> A combi or CPSU boiler which has a SEDBUK efficiency of at least 90% (band A).
Hot water store	None, unless included within boiler.
Controls (see notes 10, 11 and 12)	<ul style="list-style-type: none"> Programmable room thermostat Boiler interlock (see note 13) TRVs on all radiators, except in rooms with a room thermostat Automatic bypass valve (see note 14) <p>More advanced controls, such as weather compensation, may be considered, but at present cannot be confirmed as cost effective.</p>
Installation	See notes 1, 2, 3 and 4.

7. Energy efficiency

The information in this guide is designed to improve the energy efficiency of dwellings. Selecting the most energy efficient boilers suitable for the particular application is vital. Several factors need to be considered when choosing a boiler:

- Seasonal (i.e. annual in-use) efficiency.
- Typical heating and hot water running costs for the dwelling(s).
- Typical CO₂ emissions for space and water heating.

7.1 Comparing boiler efficiencies

The term 'boiler efficiency' needs some explanation since there are many values that may be quoted, and these are calculated in different ways. In any comparison of the efficiency of alternative products, it is essential to ensure that the same method is being used.

The efficiency value now used in the Government's Standard Assessment Procedure and in the building regulations is known by the acronym SEDBUK, (Seasonal Efficiency of a Domestic Boiler in the UK). SEDBUK represents the best estimate presently available of overall seasonal in-use boiler efficiency for space heating and hot water in UK dwellings. It is used throughout this guide as well as in CH₂ES, the Energy Saving Trust's 'Energy Efficiency Recommended' scheme, and other programmes designed to promote efficient boilers.

A boiler's SEDBUK efficiency is an indicator of the average annual boiler efficiency determined by the amount of heat delivered to the primary (boiler water) heating circuit. It is assumed that the boiler is installed in a fully-pumped system which has been correctly designed and which has adequate controls. The claimed SEDBUK efficiency level will not be achieved otherwise.

The SEDBUK calculation process (which can be found in Appendix D of the SAP^[22]) uses actual boiler test data, the measurements being taken by methods defined in European standards to meet the requirements of the European Boiler Efficiency Directive^[39]. This provides manufacturers with an incentive to make their products as efficient as possible.

Minimising demand

Whilst this guide aims to improve heating and hot water systems through careful selection of boilers and controls, it is important to remember that other factors affect the overall energy efficiency of the dwelling. In particular, it is essential to minimise:

- Fabric heat loss through walls, floors, roofs and windows.
- Ventilation heat loss from windows, unused chimneys and cracks or gaps in the structure of the dwelling.

As SEDBUK has been designed specifically for SAP energy rating purposes, it takes account of heat losses associated with space and water heating. It does not, however, include surface heat losses from any hot water store within or external to the boiler. These are treated separately as they may provide a small amount of useful heat to the dwelling during the heating season. This is important when comparing products, as stores with high heat losses will increase annual energy consumption but do not affect SEDBUK values.

The best source of SEDBUK figures is the Boiler Efficiency Database (see Section 7.5). Where this is not available, purchasers should look for this standard form of words in manufacturers' literature:

'Seasonal efficiency (SEDBUK) = [x]% The value is used in the UK Government's Standard Assessment Procedure (SAP) for energy rating of dwellings. The test data from which it has been calculated have been certified by [name and/or certification of Notified Body].'

Energy efficiency figures calculated by other methods may not be consistent with SEDBUK, and should be disregarded.

Figure 23 shows typical SEDBUK efficiencies for both new and older boilers. In practice there are limits both to the minimum efficiency due to the requirements of the Boiler Efficiency Directive, and to the maximum permitted value based on theoretical considerations.

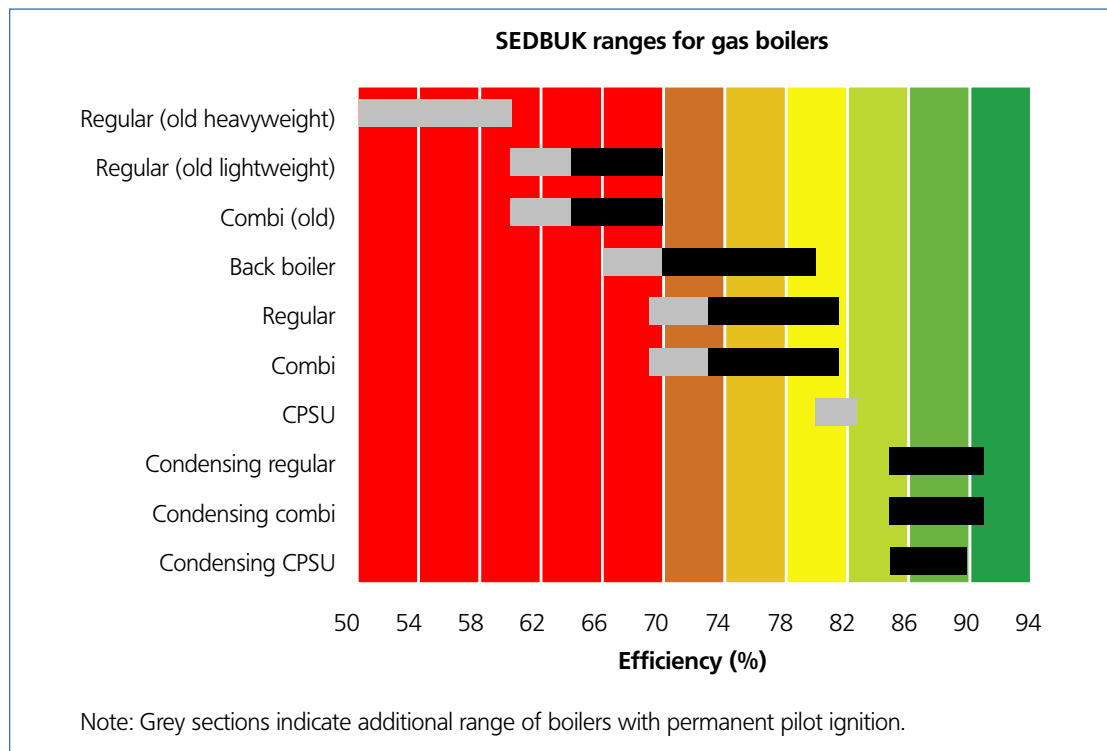


Figure 23: Typical SEDBUK values for different boiler types

7.2 The Standard Assessment Procedure (SAP)

Home energy ratings are designed to give an indication of the energy efficiency of a dwelling and so allow householders to compare different homes. The SAP is the Government's chosen rating system and indicates the running costs of space and water heating. The building regulations procedures require all new dwellings to be assessed in this way.

The current version of SAP is SAP 2005. The ratings are expressed on a scale of 1-100, with higher figures representing greater efficiency and lower running costs. Ratings above 100 are possible when the dwelling is a net exporter of energy. The actual figure depends on certain characteristics of the building and its heating systems, in particular:

- Building design.
- Insulation levels.
- Solar heat gains.
- Ventilation.
- Heating and hot water efficiency (SEDBUK) and controls.
- Energy export.

7.3 Energy consumption and running costs

Table 5 gives typical annual fuel costs for some of the more common types of dwelling found in the UK – both existing properties and new buildings. Existing housing is typical of the existing housing stock⁽⁴⁰⁾. New housing has the same floor areas for comparison, but is built with insulation levels that would satisfy the latest building regulations. The flat is on the top floor (a top floor flat has an energy consumption intermediate between a ground and mid-floor flat). Hot water costs are related to a typical number of occupants for the size of property.

Figures shown assume average UK weather conditions (the Midlands). Consumption would be around 3-6% lower in the south and 3-6% higher in the north.

Typical energy consumption has been calculated using the Building Research Establishment (BRE) Domestic Energy Model, BREDEM-12⁽⁴¹⁾. This estimates annual domestic energy usage associated with house design, insulation levels, local climate and type of heating system (including efficiency and heating usage). The model is widely used for calculating domestic fuel running costs.

Energy efficiency

Fuel costs of 1.63 and 3.71 pence per kWh are used for natural gas and bulk LPG as given in the 2005 edition of the SAP (Table 12). These costs do not include standing charges, maintenance or circulating pump running costs.

7.4 Carbon dioxide emissions

Table 6 gives typical values of annual CO₂ emissions for the same types of dwelling. Carbon intensity values are taken from SAP (2005) Table 12.

Table 5: Annual fuel (gas or LPG) costs for heating and hot water in different property types

Boiler type	SEDBUK	Existing housing					New housing				
		F	B	T	SD	D	F	B	T	SD	D
Gas - old boiler (heavy weight)	55%	£287	£361	£383	£434	£575	£92	£116	£116	£145	£172
Gas - old boiler (light weight)	65%	£243	£305	£324	£368	£486	£78	£98	£96	£123	£146
Gas - new, non-condensing	79%	£200	£251	£266	£302	£400	£65	£81	£81	£101	£120
Gas - new, condensing	90%	£175	£220	£234	£266	£351	£56	£71	£71	£89	£105
LPG - old boiler (heavy weight)	57%	£630	£792	£840	£954	£1,262	£203	£255	£255	£318	£378
LPG - old boiler (light weight)	67%	£536	£674	£715	£812	£1,074	£173	£217	£217	£271	£322
LPG - new, non-condensing	81%	£443	£557	£591	£672	£888	£143	£180	£180	£224	£266
LPG - new, condensing	92%	£390	£491	£521	£591	£782	£126	£158	£158	£197	£234

F Flat
 B Bungalow
 T Terraced
 SD Semi-detached
 D Detached

Table 6: CO₂ emission (tonne/yr) for gas or LPG heating and hot water in different property types

Boiler type	SEDBUK	Existing housing					New housing				
		F	B	T	SD	D	F	B	T	SD	D
Gas - old boiler (heavy weight)	55%	3.41	4.29	4.55	5.17	6.84	1.52	1.91	1.91	2.38	2.83
Gas - old boiler (light weight)	65%	2.89	3.63	3.85	4.38	5.79	1.28	1.62	1.62	2.02	2.40
Gas - new, non-condensing	79%	2.38	2.99	3.17	3.60	4.76	1.06	1.33	1.33	1.66	1.97
Gas - new, condensing	90%	2.09	2.62	2.78	3.16	4.18	0.93	1.17	1.17	1.46	1.73
LPG - old boiler (heavy weight)	57%	3.97	4.99	5.30	6.02	7.96	1.77	2.22	2.22	2.77	3.30
LPG - old boiler (light weight)	67%	3.38	4.25	4.51	5.12	6.77	1.50	1.89	1.89	2.36	2.80
LPG - new, non-condensing	81%	2.80	3.52	3.73	4.24	5.60	1.24	1.57	1.57	1.95	2.32
LPG - new, condensing	92%	2.46	3.09	3.28	3.73	4.93	1.09	1.38	1.38	1.72	2.04

F Flat
 B Bungalow
 T Terraced
 SD Semi-detached
 D Detached

Energy efficiency

7.5 The Boiler Efficiency Database

The Boiler Efficiency Database⁽⁴²⁾ is an independently authenticated record of the efficiency of most gas and oil-fired domestic boilers in the UK. Most of the data in it can be viewed at the website www.boilers.org.uk. Both current and obsolete boilers are included and the database is updated regularly, with a new edition issued each month.

For boilers currently on sale, the database gives SEDBUK efficiency figures derived from independently certified tests and the corresponding efficiency band (see panel). Manufacturers send details of their products to the database manager, who checks that the efficiency test results have been independently certified by an approved testing organisation and then calculates SEDBUK figures for the database entry. For obsolete boilers, where certified test results may not be available, a generic efficiency for the type of boiler concerned is quoted instead of SEDBUK.

In addition to the database, the website also has two interactive programs. The first is an annual fuel cost estimator for boilers of known efficiency in different types of housing. The second is a whole-house boiler sizing calculator to help estimate a suitable replacement boiler size for individual properties where dimensions and other relevant data are known. (See also Section 8.2).






























































As a simple guide to efficiency, SEDBUK values are divided into seven bands, from A (most efficient) to G (see panel below). The entries for each boiler on the database give the banding which may be used on product literature and labels, although there is no requirement to do so.

SEDBUK range	Band
90% and above	A
86%-90%	B
82%-86%	C
78%-82%	D
74%-78%	E
70%-74%	F
Below 70%	G

7.6 Saving energy with better controls

It is better to replace both boiler and controls when upgrading a heating system. However, in some circumstances, it may be appropriate to leave an existing boiler in place and upgrade the controls. Table 7 shows what savings could be obtained by fitting new controls (to CHES standards) to older types of boiler.

Table 7: Typical energy savings achievable by upgrading the controls on existing systems

Existing system has the following controls:					Add the following ¹ for best practice controls					Approximate average savings ² (% of the existing fuel consumption)
Older boiler with gravity DHW										
										18
										13
			 ³							12
										4
										10
Older boiler - fully pumped ⁴										
										17
										10
										4
										9
Older combi boiler ⁴										
										15
										7
										4
Key:										
 Room thermostat					 Boiler interlock					
 Programmable thermostat					 TRVs on most radiators					
 Cylinder thermostat					 Motorised valve					
<div>1. All improved systems must include a programmable room thermostat (replaces existing room thermostat).</div> <div>2. These are average savings assuming normal controls, systems and user behaviour. Actual savings may be significantly different. The savings only apply where an older-type boiler is fitted. It is assumed that the SEDBUK (see 7.1) is 60% for the Gravity DHW system and 68% for the fully-pumped and combi systems.</div> <div>3. This option provides only a partial interlock (hot water only).</div> <div>4. All improved systems should include an automatic bypass valve if a bypass circuit is necessary (see Appendix A note 14).</div>										

8. System selection: practical issues

When choosing which best practice system to install the following questions should be addressed.

1. Which boiler type is most suitable?
2. What size boiler is required?
3. Where will the boiler be positioned?
4. What will be the flue terminal position and arrangement?
5. Where does the condensate drain go?
6. Are there any special ventilation requirements?
7. Will it be an open or sealed system?
8. What type of hot water system is most suitable?
9. What type and size of heat emitters are required?
10. What controls are needed?

CHeSS (see Section 6) specifies the main components needed to achieve best practice in wet central heating systems, but there are many additional aspects of the installation to consider. The following tables outline the key points.

8.1 Which type of boiler is most suitable?^(31,43)

Regular or combi?	Best practice regular boilers (see CHeSS HR8) provide most flexibility in system design. A combi (see CHeSS HC8) incorporates some system equipment which reduces installation time.
Condensing or non-condensing?	Condensing boilers must be installed unless an exception is allowed (see panel in Section 2.2). Use condensing types as specified in CHeSS HR8 or HC8 only. These provide significantly higher efficiency than non-condensing types, although they do require connection to a drain as well as particular care in siting the flue terminal.
Instantaneous combi	The maximum flow rate at the hot water tap will depend on the boiler's heat output and the design of the draw-off pipe. Large heat outputs units (>35kW) are now available which give high water flowrates. Lower heat output versions will need more time to fill a bath or provide water at an acceptable temperature compared to storage units. Some units have a keep-hot facility which prevents any undue delay in hot water availability. This option may increase running costs.
Storage combi	These are usually capable of a higher flow rate at the hot water tap than an equivalent heat output instantaneous unit. The flow rate and the capability to sustain this will depend on the volume of the store and the boiler heat input.
CPSU	This type is capable of high flow rates at the tap due to its comparatively large store. It will also warm radiators more quickly as both the space heating and hot water are fed from this store.
Range Cooker boilers	Condensing units are now becoming available.
Back Boiler Units	These are not recommended as they are not currently available in condensing versions. Back boilers are only available in open-flue models and usually include an integral gas fire in front.
Ignition system	All Condensing boilers include automatic electronic ignition. Permanent pilot ignition (which does not meet best practice) reduces SEDBUK efficiency by around 4%.
Large boilers	For boilers with output greater than 50kW, refer to suitable publications at www.thecarbontrust.co.uk

System selection: practical issues

8.2 What size boiler is required? ^(31,35)

Maximum load	The boiler needs to be sized to meet the maximum load expected on the system. This includes the heat used by the emitters, the hot water system and the pipework.
New systems	A full design heat loss method should be employed to identify the most suitable boiler. A full design method is given in the CIBSE Domestic Heating Design Guide ⁽³²⁾ and a computer based program can be found at www.centralheating.co.uk
Boiler replacements	Size-for-size replacement is not recommended. Insulation levels may have been improved or the original sizing may have been incorrect. Heating and hot water requirements should be re-checked before a new boiler is chosen. Oversizing will result in lower efficiency and unnecessary capital costs. An interactive procedure for correctly sizing boilers up to 25kW can be found at www.boilers.org.uk
Combis	Power rating is normally determined by hot water requirements and there is generally more than enough heat output for space heating. This should always be checked in large and/or poorly insulated dwellings.

8.3 Where will the boiler be positioned? ^(31,32)

General issues	
Exception: is it difficult to install a condensing boiler?	If an exception is being considered, follow the exceptions procedure (see panel in Section 2.2) before a boiler position is considered.
Space	It has to be adequate for the boiler type (including flue pipe space).
Access	It needs to be sufficient for installation, maintenance and servicing.
Flue position	Can a flue be fitted easily? Is an extended horizontal or vertical flue required, and will angled flue bends be necessary? (See Section 8.4).
Condensate drain	Is there a suitable adjacent drain point? (See Section 8.5).
Location	
Heated area	Preferred, saves energy.
Unheated area	Requires frost protection. Consider externally mounted boiler.
Understairs	May require special provision for ventilation and fire resistance.
Bathroom, shower room, sleeping room	There are regulations regarding electrical work in bath and shower rooms. Open-flue boilers must not be installed where they can draw combustion air from a bathroom or bedroom. Room-sealed boilers should not be installed in sleeping areas if avoidable.
Roofspace, loft, attic	The weight of the boiler, ventilation and safe access must all be taken into account.
Fireplace	Condensing back boiler units (BBU) are not currently available. Where boilers are located inside a living space, particular consideration must be given to the position of the flue, the air supply routes and the provision of suitable condensate drainage.
Garage	Frost protection will be required.
Basements and cellars	Ensure a practical connection to a drain point is available – consider using a condensate pump.

System selection: practical issues

8.4 What will be the flue terminal position and arrangement? ^(32,47)

Condensing boilers	
Plume	A plume is present most of the time that the boiler operates. Avoid terminal positions where a plume would be directed: <ul style="list-style-type: none">• Towards or across a door or window.• Towards a frequently used area (e.g. patio, access route or car parking space).• Across a neighbouring dwelling or boundary.• In close proximity to an opposite wall or surface.
Freezing	Avoid situations where: <ul style="list-style-type: none">• Condensate from a terminal may drip onto a path, then freeze and cause a hazard.• The plume may condense then freeze, damaging a wall or surface.
Terminal guards	Usually required where terminal is less than 2m from ground level. These need to withstand corrosive effect of condensate.
Extended flues	If the plume may cause a nuisance, consider an extended vertical/horizontal flue, plume management option, a 'directional' terminal or alternative boiler position.

8.5 Where does the condensate drain go? ⁽⁴⁵⁾

Boiler position	Ensure the chosen drain point can be reached from the proposed boiler position.
Drain points	Condensate can be drained to: <ul style="list-style-type: none">• An internal stack pipe.• A waste pipe.• An external drain, gully or rainwater hopper.• A purpose-made small soakaway.
Boiler condensate siphons	Check whether the chosen boiler has a fitted condensate siphon. If not, externally situated condensate pipework is more likely to freeze in cold weather.
Condensate traps	Check whether the chosen boiler has an internal condensate trap with a water seal greater than 75mm. If not, an air-break and additional trap with a seal greater than 75mm must be installed.
Pipework	All pipework must have a fall of 2.5 degrees and be securely clipped. External runs must not exceed 3m and be insulated. Pipe materials must be corrosion resistant to condensate (not copper or steel).
Pipe sizes	Where there is no manufacturer's guidance: Pipes in a heated area should have a nominal diameter of at least 22mm. Externally run pipes should have a nominal diameter of at least 32mm.
Condensate pumps	If gravity will not take the condensate to the drain point, e.g. if the boiler is situated in a basement, a condensate pump will need to be considered.

System selection: practical issues

8.6 Are there any special ventilation requirements? ^(32,47)

Room sealed	Room-sealed balanced-flue appliances do not require special provision for room ventilation.
Compartment	Some boilers may require purpose made ventilation when a boiler is fitted in a compartment.

8.7 Will it be an open or sealed system? ^(31,43)

Sealed	Commonly used in new systems, especially with combis and all system boilers. They incorporate an expansion vessel. The system pressure rises with temperature. The necessary additional safety controls are normally incorporated as part of the boiler. It is important to check that this expansion vessel has enough capacity for the whole installed system.
Open	Typical of existing installations, these systems require an expansion cistern which must be at the highest point in the system.

8.8 What type of hot water system is most suitable?

Mains fed (combis, unvented cylinders, thermal stores, CPSUs)	Ensure that water supply to the dwelling (both pressure and flow rate) is adequate (with both hot and cold water running) and the mains inlet pipe is of adequate size. The flow rate obtainable from an instantaneous combi will also depend on its maximum heat output.
Storage systems	Cylinders meeting current best practice standards use high recovery coils and are well insulated. It is no longer permitted to install 'medium-duty' cylinders, which have inferior performance. Ensure existing hot water cylinders are well insulated. Cylinders of 117-140 litre capacity are usually adequate for smaller households with a single bathroom ⁽³¹⁾ .
Unvented storage	These are mains fed and usually give a high hot water flow rate at high pressure.
Thermal storage	These are also mains fed and will provide a high hot water flow rate at high pressure.
Vented storage	This type needs a cold water cistern and will usually provide a high hot water flow rate at low pressure.
Solar systems	In suitable properties, especially those with an unobstructed south-facing roof, solar water heating systems can make a significant contribution to the hot water energy requirements, and save boiler fuel. A hot water cylinder with an additional coil for connection to the solar collector system is necessary. If solar water heating is likely to be installed in the near future, it is advisable to choose a suitable cylinder at the time the main heating system is installed, as it will save cost and disruption later. Separate guidance and advice on solar water heating should be sought ^(34,46) .

System selection: practical issues

8.9 What type and size of heat emitters are required? ^(31,35)

Heat emitter type	Panel radiators offer the lowest cost option. Use Low Surface Temperature (LST) radiators where young children or elderly are likely to be present and may be at risk. Where underfloor systems are being considered refer to specialist advice ⁽³⁶⁾ .
Size	Avoid undersizing as it will result in unsatisfactory heating performance and may give rise to reduced boiler efficiency from excessive boiler cycling. If radiators are oversized ensure boiler controls are set to operate at suitable temperatures. Use a full design heat loss calculation method ⁽¹⁹⁾ . An example can be found at www.centralheating.co.uk
When used with condensing boilers	Increasing radiator sizes can reduce average boiler operating temperatures and therefore increase efficiency. However, care should be exercised when oversized radiators are installed in a room with a controlling room thermostat. If radiators in other rooms are not similarly oversized, the controllability of the whole system may be affected.
System upgrades	The heat emitters and system should be cleaned to remove deposits and sludge which reduce heating performance.

8.10 What controls are needed? ^(31,38)

Best practice	Regular boilers – use a programmable room thermostat with separate timing capability for hot water. All systems should be fully pumped, have both room and cylinder thermostats, use motorised valves or multiple pumps, and have separate zones for heating and hot water. They should also have TRVs, an automatic bypass valve and a boiler interlock. Combi boilers – use a programmable room thermostat, TRVs and boiler interlock. Install an automatic bypass valve if the manufacturer advises that a bypass should be fitted.
Basic	The basic CHSS specification is the minimum acceptable standard. The system should include a full programmer (a time switch for combis). All other controls as for best practice.
Thermostatic Radiator Valves (TRVs)	TRVs must be installed on all radiators except in rooms with a room thermostat. An automatic bypass valve must be installed if the manufacturer's instructions require one or if a minimum flow rate has to be maintained while the boiler is firing.
Pumps	Advice on pump selection is available from www.bpma.org.uk See Section 4.8 for pumps with automatic speed control.
Systems with gravity hot water	These must be converted to fully-pumped to comply with best practice and building regulation requirements.
Very large dwellings	These should be divided into separate zones not exceeding 150m ² in floor area. Each zone should be capable of independent time and temperature control.
Frost protection	This should always be considered for both the dwelling and the central heating system.
Other controls	Additional controls can also be beneficial (see Section 5.3).

9. Installing central heating systems

9.1 Competent person requirements

In England and Wales, the installation of a gas boiler requires that details of the installation are made available to CORGI who will send a certificate to the householder and supply any relevant information to the local authority building control department. Alternatively installers or their customers can use the local authority building control route for building regulation notification for which a charge is made.

Businesses or self-employed persons who install gas boilers in residential dwellings must be registered with CORGI. Full details of requirements regarding gas safety and CORGI registration can be found in the Gas Safety (Installation and Use) Regulations 1998.

Also in England and Wales all installations of unvented hot water systems must be carried out by a competent person who is approved by an appropriate body.

9.2 Installing the boiler

While condensing boilers can normally be installed in a similar location to non-condensing units, additional factors need to be considered:

- The plume from the flue terminal should not cause a nuisance.
- There must be a drain point for the condensate.

Where a boiler, particularly a replacement unit, is being installed inside a dwelling it may not be appropriate to site it in the same location. Even where it is, extended flue options may have to be considered as well as the practicalities of finding (and connecting to) a suitable drain point. Where there are particular difficulties with installing a condensing boiler, a boiler exception can be considered (see panel in Section 2.2). Even if an exception is allowed, a condensing boiler should always be considered due to increased efficiency and lower running costs.

Flue terminal position

Condensing boilers will produce a visible plume of water vapour for a significant proportion of their operating time. To avoid this causing a nuisance, a vertical flue can remove the plume to a high level.

At low level, the plume may be a nuisance. Some boilers eject flue gases horizontally in a powerful jet which may not disperse for a considerable distance. Some of the key minimum statutory distances from terminals to obstacles (such as opposite walls) are shown in figure 24. These distances are set to maintain safe operation of the appliance but in many cases will be insufficient to avoid nuisance and therefore figure 24 also gives suggested minimum distances help alleviate plume nuisance. Refer to building regulations^(47,48,49) which show all minimum statutory distances from flue terminals.

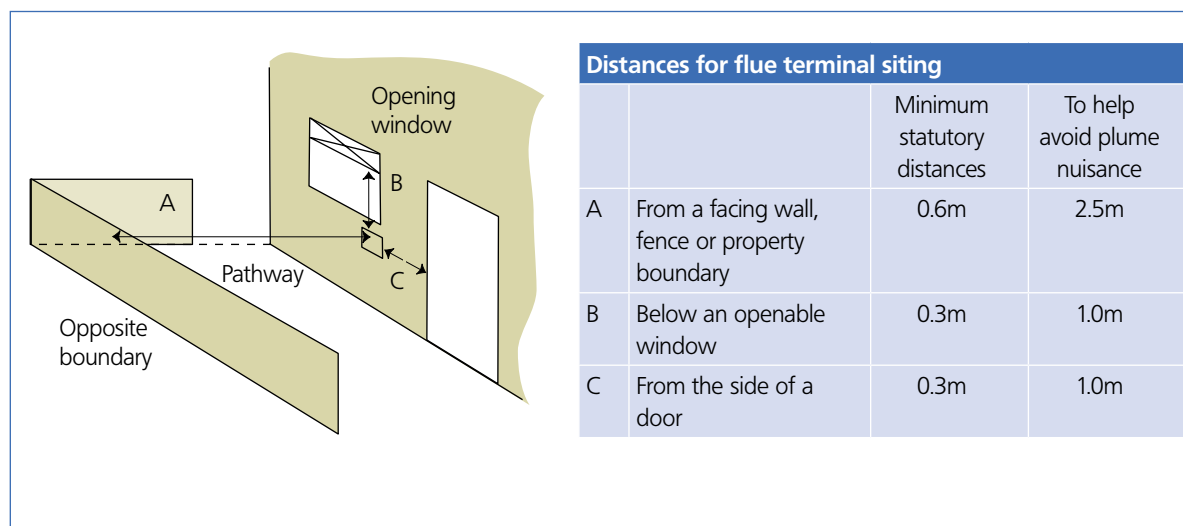


Figure 24: Wall – Flue terminal siting

Installing central heating systems

Refer to the condensing boiler exceptions procedure before the boiler/flue terminal position is decided. In any event particular care is required where it is intended to fit a flue terminal which will be positioned less than 2.5m from a facing wall, boundary fence or neighbouring property. Where the plume from a terminal may cause a nuisance, consider an extended vertical or horizontal flue or moving the boiler to an alternative position which may provide a more acceptable terminal position. Also consider a 'plume management' option and/or using a flue terminal in which the direction in which the jet of flue products can be adjusted.

The plume should not cross:

- A frequently used access route.
- Any frequently used area (such as a patio or car parking space).
- A neighbouring dwelling.

Nor should it be directed towards a window or door, or be sited close to a facing wall or other surface.

There are also other aspects to consider when planning the flue terminal position:

- A free passage of air is needed at all times to aid plume dispersal, which may be difficult in sheltered locations.
- In cold weather, the condensate could cause a safety hazard if it freezes on pathways, or if it results in frost damage to surfaces.
- The plume could trigger infra-red security lighting if sited in the wrong place.
- Ensure terminals do not obscure security camera field of vision.
- The terminal guards must be able to resist corrosive properties of the condensate.

Condensate drain point

The amount of condensate produced by a condensing boiler depends upon a number of factors but four litres a day is not unusual. The liquid is slightly acidic (a pH value of between three and six) and must be disposed of correctly. Suitable drain points include:

- An internal stack pipe.
- A waste pipe.
- An external drain or gully.

- A rainwater hopper that is part of a combined system (i.e. sewer carries both rainwater and foul water).
- A purpose-made small soakaway.

Internal drain points are to be preferred as they are less likely to become blocked by leaves, or by frozen condensate⁽⁴⁵⁾.

9.3 Installing the condensate drain pipe

Condensate traps

Building regulations require a trap to be installed in the condensate pipe from the boiler:

- If this goes straight to a gully or rainwater hopper, a water seal of at least 38mm is required.
- If connected to another waste pipe, the water seal must be at least 75mm to prevent foul smells entering the dwelling.

Internal traps already fitted within the boiler may not always satisfy the building regulations. Unless otherwise stated by the manufacturer's instructions, an additional trap of either 38mm or 75mm (depending on the proposed connection) will be required. An air break between the traps is also necessary (see figure 25).

Pipe runs

These should be as short as possible. If a condensate drainpipe runs outside the dwelling, this external run should be restricted to a maximum of 3m in order to reduce the risk of freezing. If the boiler is installed in an unheated space such as a garage, all the condensate drainpipes should be regarded as 'external'.

Pipe slope

A minimum of 2.5 degrees away from the boiler.

Bends

These should be kept to a minimum. Similarly, the number of fittings or joints outside the dwelling needs to be minimised in order to reduce the risk of condensate being trapped.

Fixings

These must be sufficient to prevent sagging. A maximum spacing of 0.5m for horizontal and 1.0m for vertical sections is recommended.

Installing central heating systems

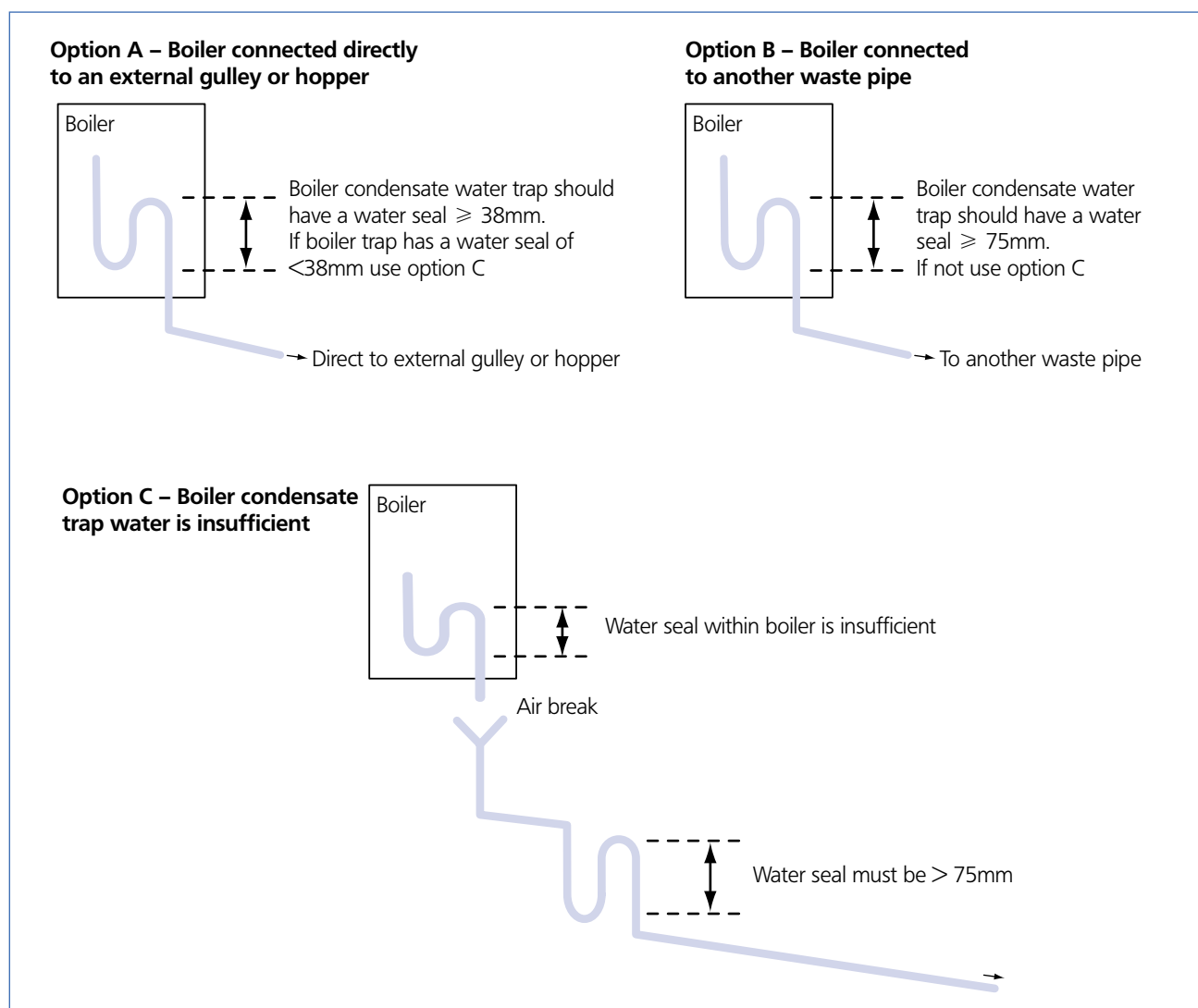


Figure 25: Condensate trap options

Pipe sizes

Follow the boiler manufacturer's instructions. In the absence of such guidance:

- The minimum nominal diameter for internal pipe runs is 22mm.
- A larger diameter (at least 32mm nominal diameter) is required for externally run pipes to reduce the risk of freezing.

Pipe materials

These should be resistant to the acid condensate. The plastics used for standard wastewater plumbing systems and cistern overflow pipes are suitable. Copper or mild steel pipes and fittings must not be used.

Condensate siphons

Many boilers have a siphon fitted as part of the condensate trap arrangement. This intermittently discharges the condensate, reducing the risk of freezing where part of the pipework runs externally. If the boiler does not include a siphon, avoid external pipework as far as possible. Where necessary it should have a minimum nominal diameter of 32mm.

Condensate pumps

These may be considered where the boiler is in the basement or a drain point cannot be reached by gravity. Pump manufacturers' instructions must always be followed.

Installing central heating systems

9.4 Condensate drain termination

Connecting to an internal stack

This is the preferred method of connection. The stack must be made of a material resistant to the corrosive effect of the condensate, such as the plastics recommended for condensate pipes.

A trap with a minimum condensate seal of 75mm is required. The boiler may incorporate a trap of this size, if not one will have to be fitted to the condensate drainpipe. A visible air break is required between this and any other trap.

For single dwellings up to three stories high, the condensate drainpipe should discharge into the stack at least 450mm above the invert of the tail of the bend at the foot of the stack. If this point is not visible, then the height should be measured from the bottom of the lowest straight section of stack to be seen. This height should be increased for buildings of more storeys.

The stack connection should not cause cross flow into any other branch pipe, nor should it allow flow from that branch into the condensate pipe. This can be ensured by maintaining an offset between branch

pipes of at least 110mm on a 100mm diameter stack, or 250mm on a 150mm stack.

Connecting to an external stack

In addition to the requirements detailed above, care must be paid to reducing any risk of the drain blocking due to the condensate freezing. The length of pipe external to the dwelling should be kept as short as possible and certainly less than 3m. Traps in the drainpipe must be inside the building. In exposed locations, the pipe should be protected with waterproof insulation.

Connecting to an internal waste pipe

The most convenient (and most frequently used) method of connection is via an internal discharge branch to a kitchen sink, washing machine or dishwasher drain. It can be connected up or downstream of the relevant waste trap and if practical should be mounted onto the top of the pipe. If connected upstream of the waste trap an air break is necessary between this trap and the boiler's own trap. This is usually provided by the sink waste pipe itself, as long as the sink has an integral overflow (see figure 27).

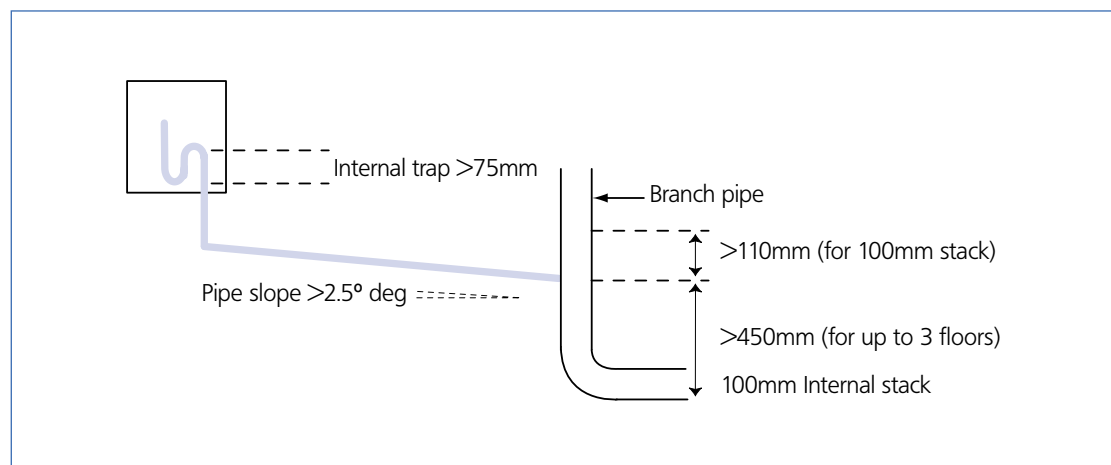


Figure 26: Condensate connection to internal stack

Installing central heating systems

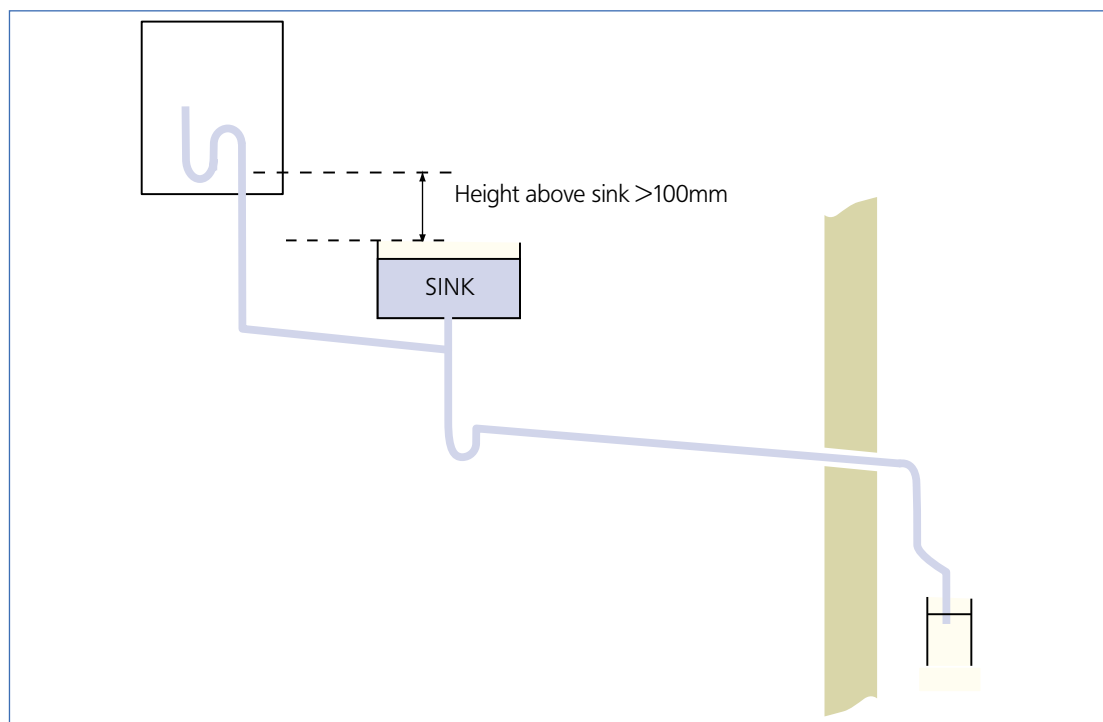


Figure 27: Connection to an internal sink waste (upstream of sink trap)

If, on the other hand, the condensate drain is connected downstream of the sink (or other appliance) waste trap, and the boiler does not have an integral trap with a seal of at least 75mm, an additional trap with that seal must be fitted. An air break must be included between the traps (see figure 28).

In either case the trap and airbreak should be above the level of the sink to prevent flows into the boiler or airbreak. It is preferable to connect to a washing machine drain rather than a kitchen sink. This reduces the likelihood of solid waste and fats blocking or restricting the condensate drain entry point.

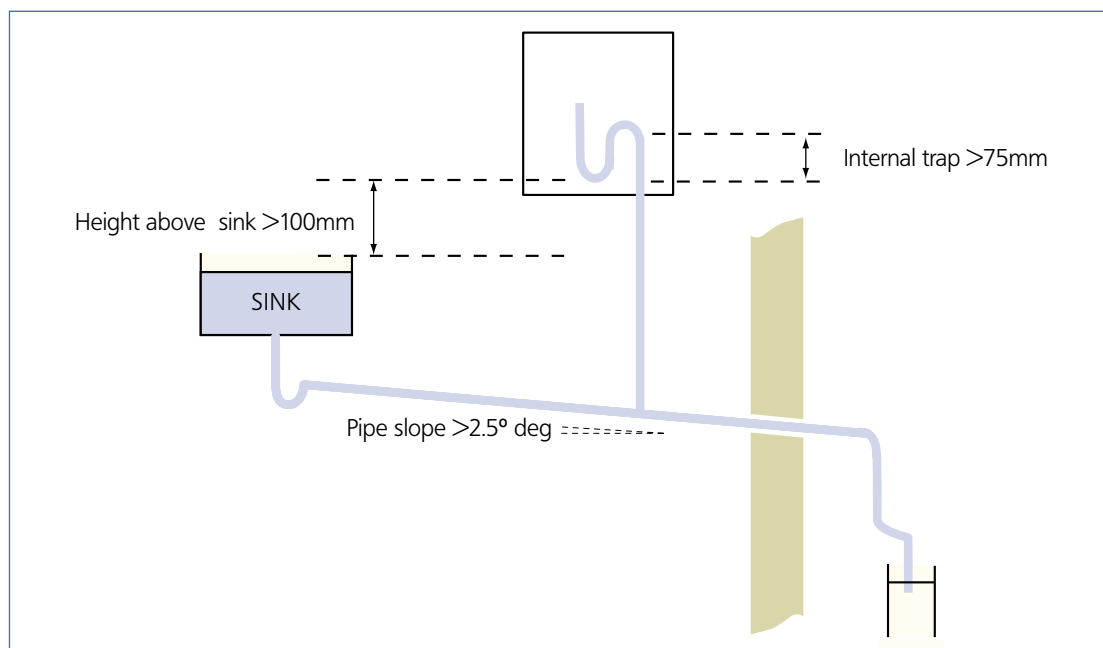


Figure 28: Connection to an internal sink waste (downstream of sink trap)

Installing central heating systems

Connecting to an external drain point

If the condensate cannot be drained via an internal route, then direct connection to an external gully or rainwater hopper can be considered. A rainwater hopper must be connected to a combined system (i.e. sewer carries both rainwater and foul water). The open end of the pipe should be below the grid level but above the water level in the gully or hopper. Condensate must not be disposed of in grey water systems.

Connecting to a small soakaway

If none of the previous solutions are possible then a purpose made soakaway can be used. It should be located as close as possible to the boiler but clear of the building foundations and not in the vicinity of other services such as gas, electricity or water

connections. The external pipework must be kept to a minimum and not more than 3m in length. The pipe may be taken below or above the ground level.

Figure 29 shows a suitable small soakaway design. It should be sited around 1m away from the building (at least 0.5m) and clear of building foundations and other services. The size of the soakaway will depend to a large extent on the soil conditions. Unlike the case of a rainwater soakaway, the soil does not have to accommodate large water volumes over short periods. A soakaway container approximately 200mm diameter and 400mm deep will normally be sufficient. The soakaway should be backfilled with limestone chippings. Note that where the soil is poorly drained, e.g. clay, this option may not be practical.

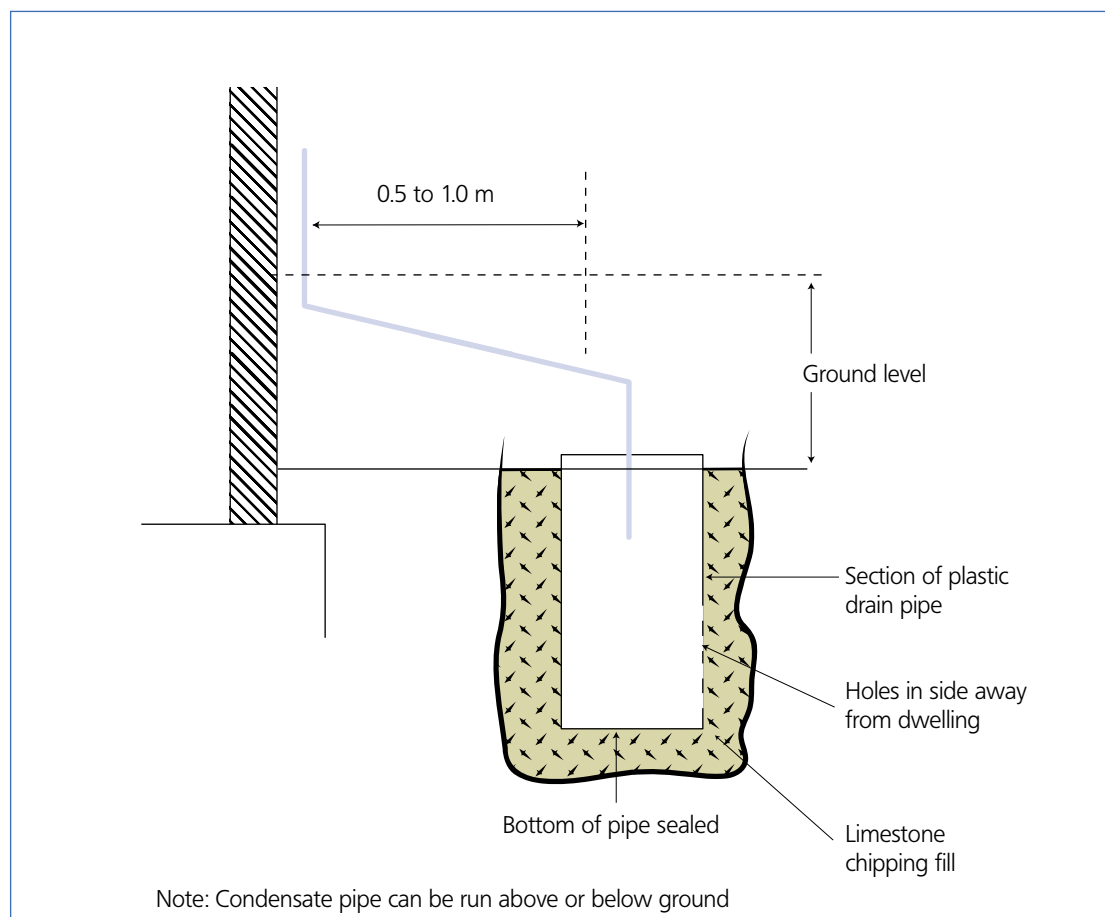


Figure 29: Possible configuration for a condensate soakaway drain

Installing central heating systems

9.5 Controls

There are a number of points to be considered when installing commonly-used central heating controls.



Programmable Room Thermostat

[CHeSS best practice specification](#)

If fitted with a regular boiler, this must have a hot water timing capability. In larger dwellings, where separate time/temperature zones are required, only one programmable room thermostat needs this hot water timing capability. A programmable room thermostat should be located in a regularly heated area. While free movement of air is important, it should be mounted away from draughts, internal heat sources and direct sunlight. It should not be fitted in a room where supplementary room heating, e.g. electric heaters or open fires can affect it. So do not site one in a kitchen or combined kitchen and living room. Only install one in a main living room if it is certain that no supplementary heating is used there. Suitable positions would be in the hall or a living room without supplementary heating.

The unit should be readily accessible to the householder, not hidden away in a cupboard or behind furniture. It should be located at a height of about 1.5m above floor level unless the occupants include wheelchair users. In this instance a suitable height in excess of 1m should be agreed with the homeowner.



Time switch/programmer

[CHeSS basic systems only](#)

Time switches can only switch one circuit (such as combi heating), while programmers can control two (e.g. heating and hot water). Ensure that the unit is suitable.

These controls should be installed where they can be easily reached, read and altered. Do not fit them in places inconvenient for the householder (e.g. in an airing cupboard).



Room thermostat

[CHeSS basic systems only](#)

Installation considerations are the same as for the programmable room thermostat.



Cylinder thermostat

[CHeSS best practice specification](#)

This control is usually strapped onto the cylinder about one third of the way up from the base. The strap needs to be tight to ensure good thermal contact and be adjusted to about 60°C. If set too high, it may result in scalding, but if too low it can increase the risk of legionella bacteria which could result in serious health problems.



Motorised valve

[CHeSS best practice specification](#)

The most common types of motorised valves are two and three-port. How each will be used depends on pipework layout and preference – as displayed in the following examples.

- Three-port valves can provide separate heating and hot water circuits. Most three-port units feature a mid-position which allows shared flow.
- Where there is more than one heating zone, as well as a hot water zone, use a separate two-port valve for each zone.
- Valves of 22mm can be used on boilers up to around 20kW. Beyond that, 28mm or larger should be used.

Note: motorised valves must not be positioned in the line of the open safety vent pipe or the feed-and-expansion pipe.



Thermostatic Radiator Valve (TRV)

[CHeSS basic and best practice specifications](#)

TRVs must be used in systems meeting either specification. They should be installed in all rooms except those in which a controlling room thermostat provides a boiler interlock. Many TRVs can be fitted on the flow or return to the radiator and many are bi-directional. If not, the direction of the water flow must be taken into account when installing them.

Installing central heating systems



Automatic bypass valve

CHeSS basic and best practice specifications

These should be used for systems meeting either specification unless the boiler manufacturer does not require a bypass circuit be fitted to ensure a minimum flow rate. The valve should be installed between the boiler primary flow and return, taking account of the direction of flow. Ensure that the valve has adequate flow capacity. It should be set so as to ensure adequate flow through the boiler when all motorised valves and/or TRVs are closed.

The outline setting procedure is as follows:

- Once the system is commissioned and balanced, make a note of the selected pump speed.
- Determine the minimum flow requirement of the boiler (from manufacturer's instructions).
- From the pump manufacturer's pump curve at the selected pump speed, determine available pump head at the required minimum flow.
- Using the manufacturer's automatic bypass setting chart, adjust the valve setting to correspond to the pump head at the minimum flow.

Should persistent water velocity noise occur in the system, gradually reduce the valve setting until the noise is eliminated.



Frost protection (air and pipe thermostat)

Where both air and pipe thermostats are used, the contacts should be wired in series from a live supply* that is not switched by a timeswitch/programmer or thermostats. This ensures that protection is available 24 hours a day. Some boilers already include their own frost protection, but the level of protection for the whole dwelling needs to be considered.

* For units that require thermostats with voltage-free contacts, refer to the manufacturer's instructions.

Weather compensator or unit with external sensor

The external sensor should be positioned on a north-facing wall, away from direct sunlight and other heat sources.

9.6 Water treatment

Effective water treatment of a central heating system is essential to ensure continued efficient and trouble free operation.

Key points are:

- Both new and existing systems should be thoroughly cleaned and flushed out before a new boiler is fitted.
- A suitable corrosion inhibitor should be used in the boiler primary water circuit to minimise corrosion and the formation of scale and sludge.
- The water supply may require softening to prevent scaling of heat exchangers. This is particularly important in the case of water heaters which are installed in hard water areas (where the water hardness exceeds 200 parts per million. See BS 7593:2006⁽⁵⁷⁾).
- Always refer to boiler manufacturer's instructions to ensure appropriate cleaning, softening and inhibitor products are used and any special requirements for particular models are applied.
- A system with excessive hardness scale and sludge will not operate at optimal efficiency.

More advice is available on water treatment, the need for it, methods and dealing with problems^(56,57).

10. Commissioning and handover

10.1 Commissioning

For safe and energy-efficient operation, all parts of a new central heating and hot water system need to be checked to ensure they are working properly. In particular:

- The boiler and system should be cleaned using a recognised flushing procedure (see BS 7593:2006).
- A suitable corrosion inhibitor should be used in the boiler primary water circuit to minimise corrosion and the formation of scale and sludge (subject to recommendations by the boiler manufacturer).
- The key system components must be checked for correct and safe operation.
- The controls should be set to their optimum settings.
- The customer should be instructed on how to operate the controls, and the importance of regularly servicing the system needs to be made clear.

In England and Wales, a CORGI registered installer will carry out this work and they will send details to CORGI who will send certificates to the householder and the local authority Building Control. Alternatively installers or their customers can use the local authority Building Control route for notification.

To raise the standard of the installation, commissioning and servicing of central heating systems in the UK, the Benchmark scheme has been introduced. It is intended to ensure that all new boilers are both safe and energy efficient throughout their working life. Most new boilers will have a log book. This should be signed by a CORGI registered installer to confirm the boiler has been fitted and commissioned in accordance with the manufacturer's instructions. Householders will be encouraged to ask the installer for this log book and to retain it for evidence of correct installation, commissioning and servicing of the boiler and systems.

10.2 Advising householders

Installers must instruct the householder how to set and use the controls properly and effectively. In particular, the operation of programmers can be difficult to understand and homeowners will gain little or no benefit from an incorrectly set device. In fact, they will probably end up wasting energy.

As a bare minimum, the manufacturer's instructions should be left with the householder. However, it will usually be necessary to demonstrate:

- How to set the programmer clock and adjust for GMT and BST.
- The use of the time control override function.
- How to set summer hot water only.
- How to separate space heating and domestic hot water time settings (regular boilers only).
- How to set room and cylinder thermostats.
- How to set TRVs.

The installer will also need to explain:

- The function of room thermostats and TRVs and the need to set them carefully to avoid wasteful heating. They should be altered when the needs of the household change, and should not be treated as on/off switches.
- That the cylinder thermostat needs to be left at approximately 60°C, since setting it higher may result in scalding while setting it lower can allow the growth of legionella bacteria.
- That the radiator lockshield and automatic bypass valve should not be adjusted once set by the installer.
- Why it is best to switch space and water heating off when not required.
- Why it is best to turn the room thermostat down to frost protection levels (approximately 12°C) unless a separate frost protection system has been fitted.
- That sealed boiler systems must have adequate system pressure and what to do if re-pressurising is needed.

10.3 Servicing

Users should be made aware of the importance of regular servicing, both of the boiler and the system as a whole. This will help maintain its safety and efficiency. In particular, users should consider taking out a regular service contract where a competent service engineer (registered with CORGI) will clean and maintain the boiler, check the operation of the system and controls, as well as completing the record of servicing in the Benchmark log book.

Note that homeowners in England and Wales can now ask for a energy rating for their boiler with advice on how to cut fuel bills, whenever an engineer makes a regular service visit. An example of the form used in shown in Appendix D.

Appendix A – Notes to CHeSS 2008

CHeSS is published in full as reference⁽³⁸⁾ and part of it is reproduced here in Section 6. The Notes below apply to CHeSS HR7, HC7, HR8, HC8 (Year 2008).

1. Other components

The specifications list only the principal components of a heating system affecting energy efficiency. Other components will be required, such as radiators, circulator pumps (see note 4), cisterns (feed and expansion tanks), and motorised valves. All components must be selected and sized correctly.

2. Design, installation and commissioning

Heating systems should be designed to match the heating needs of the buildings in which they are installed, using methods such as those described in Ref [5]. They should be installed in accordance with relevant safety regulations, manufacturers' instructions, the Benchmark scheme (see Ref [10]), building regulations (see Refs [1], [2], [11]), the Domestic Heating Compliance Guide (see Ref [16]), and British Standards (see Refs [12], [13], [17], [18]). For oil boilers the OFTEC forms CD/10 and CD/11 (or similar) for installation and commissioning should be completed. More detailed advice on domestic wet central heating systems is given in the Energy Saving Trust guides (see Refs [3] and [4]), and the CIBSE guide (see Ref [5]). Commissioning and handover of information on operation and maintenance is a requirement of building regulations and a suitable commissioning certificate should be issued.

3. Water treatment

Water treatment is important as it prolongs effective and trouble-free operation. Three types of water treatment should be considered:

- Cleaning and flushing of the system before use
- Corrosion inhibition
- Softening of the water supply to combi boilers for hot water service in hard water areas.

In each case the recommendation of the boiler manufacturer must be followed as damage may be caused by unsuitable treatment. For both new and replacement systems, thorough cleaning is essential. When a boiler is replaced it is essential to drain and flush all old water from the system in case it contains a corrosion inhibitor unsuitable for the new boiler. Advice on the need for treatment and on causes of problems is given in BS 7593 (see Ref [14]).

4. Circulator pump

Advice on pump dimensioning is available from the BPMA (British Pump Manufacturers' Association) website at www.bpma.org.uk

Pumps installed separately from the boiler (not supplied as part of the boiler unit) which have automatic speed control should not be used in heating systems with TRVs unless the design of the pump and system ensures that the minimum flow rate through the boiler (as specified by the boiler manufacturer) is certain to be maintained under all conditions.

5. Boiler size and type

The whole house boiler sizing method for houses and flats gives guidance on boiler size and is available on the Energy Saving Trust website at www.energysavingtrust.org.uk/housingbuildings/calculators/boilersizing

A **regular boiler** does not have the capability to provide domestic hot water directly, though it may do so indirectly via a separate hot water store.

A **combination (combi) boiler** does have the capability to provide domestic hot water directly, and some models contain an internal hot water store.

A **combined primary storage unit (CPSU)** is a boiler with a burner that heats a thermal store directly.

Each of these may be either a condensing or non-condensing boiler, and condensing boilers are always more efficient. Condensing boilers are fitted with a drain to dispose of the liquid condensate. Building regulations require all new gas and oil boilers to be condensing, whether installed in new or existing housing, unless there are exceptional circumstances that would make the installation impractical or excessively costly. All boilers in the CHeSS specifications HR7, HC7, HR8 and HC8 are condensing boilers.

For further definitions of boiler types see Appendix D of Ref [6].

6. Boiler efficiency

SEDBUK (Seasonal Efficiency of Domestic Boilers in the UK) is the preferred measure of the seasonal efficiency of a boiler installed in typical domestic conditions in the UK, and is used in SAP assessments and the building regulations. The SEDBUK efficiency of most current and obsolete boilers can be found on the website

www.boilers.org.uk. Although SEDBUK is expressed as a percentage, an A to G scale of percentage bands has also been defined below.

SEDBUK	
Efficiency range	Band
90% and above	A
86% – 90%	B
82% – 86%	C
78% – 82%	D
74% – 78%	E
70% – 74%	F
Below 70%	G

7. Hot water cylinder (basic)

Vented cylinders shall comply with the performance requirements of BS 1566:2002 Type P cylinders (see Ref [7]). The performance of unvented cylinders shall comply with BS EN 12897:2006 (see Ref [8]) or be approved by the BBA or other equivalent body. All cylinders must be factory insulated such that the standing heat loss will not exceed:
 $1.6 \times (0.2 + 0.051 V^{2/3})$ kWh per 24 hours, where V is the capacity in litres. All cylinders shall be labelled with the standing heat loss in kWh/24hours.

Indirect cylinders shall also be labelled with the heat exchanger performance in kW as measured by BS 1566: 2002 (vented) or BS EN 12897 (unvented). Where cylinder capacity (V) in litres is less than 200, the ratio of V to heat exchanger performance (in kW) shall not exceed 10; e.g. a 150 litre cylinder shall have a minimum heat exchanger performance of 15kW. Where V is 200 or above the cylinder shall have a minimum heat exchanger performance of 20kW.

8. Hot water cylinder (high performance)

A high performance cylinder may be either vented or unvented. The manufacturer must confirm that the heat exchanger and insulation properties exceed the requirements of the relevant British Standards (see Refs [7], [8]). The standing heat loss must not exceed: $1.28 \times (0.2 + 0.051 V^{2/3})$ kWh per 24 hours, where V is the capacity in litres. All cylinders shall be labelled with the standing heat loss in kWh/24hours.

High performance cylinders shall comply with the heat exchanger performance and labelling requirements of basic cylinders, as set out in Note 7.

Solar-compatible cylinders contain an additional heat exchanger or other provision for connection to a solar water heating system. They offer the opportunity to install a solar water heating system at greatly reduced cost and with less disruption in the future. In the case of solar-compatible cylinders the heat exchanger performance of the upper coil (connected to the boiler) shall relate to the volume of water heated by that coil; i.e. the dedicated solar volume shall be subtracted from the total cylinder capacity for the purposes of heat exchanger assessment.

9. Thermal store (high performance)

A high-performance thermal (primary) storage system must have insulation properties exceeding by at least 15% those given in the WMA Performance Specification for Thermal Stores (see Ref [9]), and comply with the specification in other respects. Note that the WMA Performance Specification for Thermal Stores is shortly to be superseded by a revised 2008 specification from the HWA (Hot Water Association).

10. Circuits and zones

Systems with regular boilers must have separately controlled circuits to the hot water cylinder and radiators, and both circuits must have pumped circulation. Large properties must be divided into zones not exceeding 150m² floor area, so that the operation of the heating in each zone can be timed and temperature controlled independently.

11. Heating controls

Definitions of heating controls are given in Ref [4]. The most common are repeated below.

A **time switch** is an electrical switch operated by a clock to control either space heating or hot water, or both together but not independently.

A **full programmer** allows the time settings for space heating and hot water to be fully independent.

A **room thermostat** measures the air temperature within the building and switches the space heating on and off. A single target temperature may be set by the user.

A **programmable room thermostat** is a combined time switch and room thermostat that allows the user to set different periods with different target temperatures for space heating, usually in a weekly cycle. Some models also allow time control of hot water, therefore replacing a full programmer.

A **cylinder thermostat** measures the temperature of the hot water cylinder and switches the water heating on and off.

A **thermostatic radiator valve (TRV)** has an air temperature sensor which is used to control the heat output from the radiator by adjusting water flow.

12. Wireless controls

Wireless controls are susceptible to radio transmissions and should therefore be designed to a satisfactory level of immunity, otherwise they may become unreliable as nearby frequency bands become increasingly utilised by communication services.

Compliance with the essential requirements of the European Radio and Telecommunications Terminal Equipment (RTTE) Directive 1999/5/EC is insufficient, as the directive is designed only to ensure that wireless products do not cause harmful interference to other transmissions. It does not give any assurance that the product has a satisfactory level of immunity to interference from other radio transmissions.

Consequently it is not sufficient for the manufacturer to confirm compliance with the RTTE Directive. The manufacturer should also confirm that the switching range, and preferably alignment range, do not include any frequencies below 430MHz, and that in regard to ETSI EN 300 220-1 v1.3.1 (see Ref [15]) the receiver classification (clause 4.1.1) is either Class 1 or Class 2, and the device is marked in accordance with clause 4.3.4.

13. Boiler interlock

Boiler interlock is not a physical device but an arrangement of the system controls (room thermostats, programmable room thermostats, cylinder thermostats, programmers and time switches) so as to ensure that the boiler does not fire when there is no demand for heat.

In a system with a combi boiler this can be achieved by fitting a room thermostat. In a system with a regular boiler this can be achieved by correct wiring interconnection of the room thermostat, cylinder thermostat, and motorised valve(s). It may also be achieved by more advanced controls, such as a boiler energy manager. TRVs alone are not sufficient for boiler interlock.

14. An automatic bypass valve

An automatic bypass valve controls water flow in accordance with the water pressure across it, and is used to maintain a minimum flow rate through the boiler and to limit circulation pressure when alternative water paths are closed.

A bypass circuit must be installed if the boiler manufacturer requires one, or specifies that a minimum flow rate has to be maintained while the boiler is firing. The installed bypass circuit must then include an automatic bypass valve (not a fixed-position valve).

Care must be taken to set up the automatic bypass valve correctly, in order to achieve the minimum flow rate required (but not more) when alternative water paths are closed.

Appendix B – Definitions of boiler types

B1.1 Boiler

A gas or liquid fuelled appliance designed to provide hot water for space heating. It may (but need not) be designed to provide domestic hot water as well.

B1.2 Condensing boiler

A boiler designed to make use of the latent heat released by the condensation of water vapour in the combustion flue products. The boiler must allow the condensate to leave the heat exchanger in liquid form by way of a condensate drain. Condensing may only be applied to the definitions B1.3 to B1.14 inclusive. Boilers not so designed, or without the means to remove the condensate in liquid form, are called 'non-condensing'.

B1.3 Regular boiler

A boiler which does not have the capability to provide domestic hot water directly (i.e. not a combination boiler). It may nevertheless provide domestic hot water indirectly via a separate hot water storage cylinder.

B1.4 On/off regular boiler

A regular boiler without the capability to vary the fuel burning rate whilst maintaining continuous burner firing. This includes those with alternative burning rates set once only at time of installation, referred to as range rating.

B1.5 Modulating regular boiler

A regular boiler with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

B1.6 Combination boiler

A boiler with the capability to provide domestic hot water directly, in some cases containing an internal hot water store.

B1.7 Instantaneous combination boiler

A combination boiler without an internal hot water store, or with an internal hot water store of capacity less than 15 litres.

B1.8 On/off instantaneous combination boiler

An instantaneous combination boiler that only has a single fuel burning rate for space heating. This includes appliances with alternative burning rates set once only at time of installation, referred to as range rating.

B1.9 Modulating instantaneous combination boiler

An instantaneous combination boiler with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

B1.10 Storage combination boiler

A combination boiler with an internal hot water store of capacity at least 15 litres but less than 70 litres, OR a combination boiler with an internal hot water store of capacity at least 70 litres, in which the feed to the space heating circuit is not taken directly from the store. If the store is at least 70 litres and the feed to the space heating circuit is taken directly from the store, treat as a CPSU (B1. 13 or B1. 14).

B1.11 On/off storage combination boiler

A storage combination boiler that only has a single fuel burning rate for space heating. This includes appliances with alternative burning rates set once only at time of installation, referred to as range rating.

B1.12 Modulating storage combination boiler

A storage combination boiler with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

B1.13 On/off combined primary storage unit (CPSU)

A single appliance designed to provide both space heating and the production of domestic hot water, in which there is a burner that heats a thermal store which contains mainly primary water which is in common with the space heating circuit. The store must have a capacity of at least 70 litres and the feed to the space heating circuit must be taken directly from the store. The appliance does not have the capability to vary the fuel burning rate whilst maintaining continuous burner firing. This includes those with alternative burning rates set once only at time of installation, referred to as range rating.

B1.14 Modulating combined primary storage unit (CPSU)

A single appliance designed to provide both space heating and the production of domestic hot water, in which there is a burner that heats a thermal store which contains mainly primary water which is in common with the space heating circuit. The store must have a capacity of at least 70 litres and the feed to the space heating circuit must be taken directly from the store. The appliance has the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

Definitions of boiler types

B1. 15 Low temperature boiler

A non-condensing boiler designed as a low temperature boiler and tested as a low temperature boiler as prescribed by the Boiler Efficiency Directive (i.e. the part load test was carried out at average boiler temperature of 40°C).

B1. 16 Keep-hot facility

A facility within an instantaneous combination boiler whereby water within the boiler may be kept hot while there is no demand. The water is kept hot either (i) solely by burning fuel, or (ii) by electricity, or (iii) both by burning fuel and by electricity, though not necessarily simultaneously.

Appendix C – Definitions of heating controls

As given in SAP Appendix D⁽²²⁾ The list of definitions has been discussed and agreed with industry representatives, and, for completeness, includes some controls for heating systems other than gas central heating.

Automatic bypass valve

A valve to control water flow, operated by the water pressure across it. It is commonly used to maintain a minimum flow rate through a boiler and to limit circulation pressure when alternative water paths are closed (particularly in systems with TRVs).

Boiler anti-cycling device

A device to introduce a time delay between boiler firing. Any energy saving is due to a reduction in performance of the heating system. The device does not provide boiler interlock.

Boiler auto ignition

An electrically controlled device to ignite the boiler at the start of each firing, avoiding use of a permanent pilot flame.

Boiler energy manager

No agreed definition, but typically a device intended to improve boiler control using a selection of features such as weather compensation, load compensation, optimum start control, night setback, frost protection, anticycling control and hot water override.

Boiler interlock

This is not a physical device but an arrangement of the system controls so as to ensure that the boiler does not fire when there is no demand for heat. In a system with a combi boiler it can be achieved by fitting a room thermostat. In a system with a regular boiler it can be achieved by correct wiring interconnections between the room thermostat, cylinder thermostat, and motorised valve(s). It may also be achieved by a suitable boiler energy manager.

Boiler modulator (air temperature)

A device, or feature within a device, to vary the fuel burning rate of a boiler according to measured room temperature. The boiler under control must have modulating capability and a suitable interface for connection.

Boiler modulator (water temperature)

A device, or feature within a device, to vary the fuel burning rate of a boiler according to measured water temperature. It is often fitted within the boiler casing. The boiler under control must have modulating capability.

Boiler thermostat

A thermostat within the boiler casing to limit the temperature of water passing through the boiler by switching off the boiler. The target temperature may either be fixed or set by the user.

CELECT-type electric heating control

Integrated central control system for electric storage and panel heaters that provides programmed space temperatures at different times of the day for a number of separate heating zones in the dwelling. It minimises the charge period of the storage heaters according to the external temperature.

Cylinder thermostat

A sensing device to measure the temperature of the hot water cylinder and switch on and off the water heating. A single target temperature may be set by the user.

Delayed start

A device, or feature within a device, to delay the chosen starting time for space heating according to the temperature measured inside or outside the building.

Frost thermostat

A device to detect low air temperature and switch on heating to avoid frost damage, arranged to override other controls.

Load compensator

A device, or feature within a device, which adjusts the temperature of the water circulating through the heating system according to the temperature measured inside the building.

Motorised valve

A valve to control water flow, operated electrically. A two-port motorised valve controls water flow to a single destination. A three-port motorised valve controls water flow to two destinations (usually for space heating and hot water), and may be either a diverter valve (only one outlet open at a time) or a mid-position valve (either one, or both, outlets open at a time). The valve movement may also open or close switches, which are used to control the boiler and pump.

Definitions of heating controls

Night setback

A feature of a room thermostat that allows a lower temperature to be maintained outside the period during which the normal room temperature is required.

On/off-peak hot water controller

A control to switch the electrical supply to the main immersion heater from the off-peak electricity supply. It may also include a boost function so that some of the stored water can also be heated using on-peak electricity.

Optimum start

A device, or feature within a device, to adjust the starting time for space heating according to the temperature measured inside or outside the building, aiming to heat the building to the required temperature by a chosen time.

Optimum stop

A device, or feature within a device, to adjust the stop time for space heating according to the temperature measured inside (and possibly outside) the building, aiming to prevent the required temperature of the building being maintained beyond a chosen time.

Pipe thermostat

A switch governed by a sensor measuring pipe temperature, normally used in conjunction with other controls such as a frost thermostat.

Programmable cylinder thermostat

A combined time switch and cylinder thermostat that allows the user to set different periods with different target temperatures for stored hot water, usually in a daily or weekly cycle.

Programmable room thermostat

A combined time switch and room thermostat that allows the user to set different periods with different target temperatures for space heating, usually in a daily or weekly cycle.

Programmer

Two switches operated by a clock to control both space heating and hot water. The user chooses one or more periods, usually in a daily or weekly cycle. A mini-programmer allows space heating and hot water to be on together, or hot water alone, but not heating alone. A standard programmer uses the same time settings for space heating and hot water.

A full programmer allows the time settings for space heating and hot water to be fully independent.

Pump modulator

A device to reduce pump power when not needed, determined by hydraulic or temperature conditions or firing status of the boiler.

Pump over-run

A timing device to run the heating system pump for a short period after the boiler stops firing to discharge very hot water from the boiler heat exchanger.

Room thermostat

A sensing device to measure the air temperature within the building and switch on and off the space heating. A single target temperature may be set by the user.

Self-adaptive (or self-learning) control

A characteristic of a device (of various types) that learns from experience by monitoring, and modifies its subsequent behaviour accordingly.

Temperature and time zone control (or full zone control)

A control scheme in which it is possible to select different temperatures at different times in two (or more) different zones.

Time switch

An electrical switch operated by a clock to control either space heating or hot water, or both together but not independently. The user chooses one or more 'on' periods, usually in a daily or weekly cycle.

Thermostatic radiator valve

A radiator valve with an air temperature sensor, used to control the heat output from the radiator by adjusting water flow.

Weather compensator

A device, or feature within a device, that adjusts the temperature of the water circulating through the heating system according to the temperature measured outside the building.

Zone control

A control scheme in which it is possible to select different times and/or temperatures in two (or more) different zones.

Appendix D – Energy efficiency checklist



Gas fired Home Heating Installations – energy efficiency checklist

This energy assessment is *not* a service or safety check. You should ensure your heating system is regularly maintained and inspected by a competent heating engineer to ensure its safety and efficiency.

This is part of an initiative to help homeowners cut their fuel bills and reduce their carbon emissions.

Section 1 – Installation information

Customer Name	
Installation Address	
Customer Address (if different)	
Date of assessment	

Section 2 – Stored Hot Water Systems (if applicable)

Are the water pipes connected to the cylinder insulated?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Does the hot water cylinder have spray foam insulation or a jacket with a thickness greater than 75mm?	Yes <input type="checkbox"/>	No <input type="checkbox"/>

Section 3 – Heating Controls

Does the system incorporate time control?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Does the system have thermostatic radiator valves (TRV)?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Does the system have room thermostat(s) and boiler interlock ¹ ?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Does the hot water cylinder have a thermostat and boiler interlock ¹ ?	Yes <input type="checkbox"/>	No <input type="checkbox"/>

¹ Boiler interlock ensures the boiler and pump shuts down when heating and/or hot water are at the required temperature

Section 4 – Boiler

Manufacturer		Approximate Age	
Model name/number			
The Energy Efficiency of your boiler			
<input type="checkbox"/> High efficiency (A-C rating) <input type="checkbox"/> D rated <input type="checkbox"/> E rated <input type="checkbox"/> F rated <input type="checkbox"/> High G rated <input type="checkbox"/> Low G rated			

Section 5 – Energy Efficiency Assessment

A brief inspection of your heating system has been carried out in accordance with recommended industry good practice. Depending upon the outcome of this inspection there may be an opportunity for you to improve the energy efficiency of the system, thereby reducing emissions to the environment and at the same time reducing your fuel bills.

In any of the following cases you are strongly advised to obtain a more thorough examination of your boiler and complete heating system by a competent heating engineer.

- If any of the answers in Sections 2 and 3 are 'No',
- If the boiler is rated D or below
- If the boiler is more than 15 years old or if a complete examination of the design and condition of your heating system has not been carried out in the last 15 years.

Name of service engineer	
Signature of service engineer	

Energy efficiency checklist

Potential savings – all information is provided by the Energy Saving Trust



Improving your heating system and controls	Typical Annual saving up to (£/yr)	CO ₂ savings
Insulating hot water pipes connected to the hot water cylinder	£10	70 kg/yr
Insulating your hot water cylinder with a jacket thicker than 75mm	£20	160 kg/yr
Installing heating controls	£65	530 kg/yr
Changing from a D rated boiler to an A rated boiler could save you:	£54	420 Kg/yr
Changing from an E rated boiler to an A rated boiler could save you:	£77	600 Kg/yr
Changing from an F rated boiler to an A rated boiler could save you:	£104	800 Kg/yr
Changing from a High G rated boiler to an A rated boiler could save you:	£157	1.2 tonnes/yr
Changing from a Low G rated boiler to an A rated boiler could save you:	£258	2.0 tonnes/yr
Other possible home improvements	Typical Annual saving up to (£/yr)	CO ₂ savings
Cavity Wall insulation	£90	750 kg/yr
Solid Wall insulation (internal)	£300	2.4 tonnes/yr
Solid Wall insulation (external)	£300	2.6 tonnes/yr
Double glazing	£90	740 kg/yr
Loft insulation (new installation to a thickness of 270mm)	£110	930 kg/yr
Floor insulation	£45	370 kg/yr
Draught proofing	£20	155 kg/yr
Filling gaps between floor and skirting board	£15	130 kg/yr

The savings shown are approximate and are provided as an *illustration* only. They are based on a natural gas heated semi-detached house with 3 bedrooms, using a gas price of 2.51p/kWh. Some of the savings made may be taken in increased comfort. The actual annual savings will vary depending on the type of appliance, size and age of house and type of fuel used. If you implement more than one of the improvements, the total savings may be less than the sum of the individual savings.

An Energy Performance Certificate will give you an energy rating for your home and *specific* recommendations and savings for your property. Energy Performance Certificates (EPCs) are a legal requirement within a Home Information Pack for the marketed sales of homes. EPCs will be required for homes when rented from 1 October 2008.

For advice on how to take action and to find out about offers available to help make your home more energy efficient, call **0800 512 012** or visit www.energysavingtrust.org.uk/myhome

To determine what size boiler you need for your home: visit www.sedbuk.com and click on 'Recommended Boiler Size'. By providing some basic details about the size of your home, you can see what size of boiler you need.

For a more thorough inspection of your heating system you should contact a competent heating engineer with an energy efficiency qualification.

Contact CORGI if you have any concerns about the safety of your gas appliance or to check your installer is CORGI registered on **0800 915 0485** or visit www.trustcorgi.com.

Address Details

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Appendix E – Heating controls: simple explanations for householders

Simple explanations of the purpose and principles of domestic heating controls are necessary to help householders understand them, and encourage more effective usage. The following pages have been written in conjunction with control manufacturers to accompany the installation and commissioning instructions for individual products, and are included with heating controls that carry the Energy Saving Recommended logo.

1. What is a room thermostat?

A room thermostat simply switches the heating system on and off as necessary. It works by sensing the air temperature, switching on the heating when the air temperature falls below the thermostat setting, and switching it off once this set temperature has been reached.

Turning a room thermostat to a higher setting will not make the room heat up any faster. How quickly the room heats up depends on the design of the heating system, for example, the size of boiler and radiators.

Neither does the setting affect how quickly the room cools down. Turning a room thermostat to a lower setting will result in the room being controlled at a lower temperature, and saves energy.

The heating system will not work if a time switch or programmer has switched it off.

The way to set and use your room thermostat is to find the lowest temperature setting that you are comfortable with, and then leave it alone to do its job. The best way to do this is to set the room thermostat to a low temperature – say 18°C – and then turn it up by one degree each day until you are comfortable with the temperature. You won't have to adjust the thermostat further. Any adjustment above this setting will waste energy and cost you more money.

If your heating system is a boiler with radiators, there will usually be only one room thermostat to control the whole house. But you can have different temperatures in individual rooms by installing thermostatic radiator valves (TRVs) on individual radiators. If you don't have TRVs, you should choose a temperature that is reasonable for the whole house. If you do have TRVs, you can choose a slightly higher setting to make sure that even the coldest room is comfortable, then prevent any overheating in other rooms by adjusting the TRVs.

Room thermostats need a free flow of air to sense the temperature, so they must not be covered by curtains or blocked by furniture. Nearby electric fires, televisions, wall or table lamps may prevent the thermostat from working properly.

2. What is a cylinder thermostat?

A cylinder thermostat switches on and off the heat supply from the boiler to the hot-water cylinder. It works by sensing the temperature of the water inside the cylinder, switching on the water heating when the temperature falls below the thermostat setting, and switching it off once this set temperature has been reached.

Turning a cylinder thermostat to a higher setting will not make the water heat up any faster. How quickly the water heats up depends on the design of the heating system, for example, the size of boiler and the heat exchanger inside the cylinder.

The water heating will not work if a time switch or programmer has switched it off. And the cylinder thermostat will not always switch the boiler off, because the boiler sometimes needs to heat the radiators.

Cylinder thermostats are usually fitted between one quarter and one third of the way up the cylinder. The cylinder thermostat will have a temperature scale marked on it, and it should be set at between 60°C and 65°C, then left to do its job. This temperature is high enough to kill off harmful bacteria in the water, but raising the temperature of the stored hot water any higher will result in wasted energy and increase the risk of scalding.

If you have a boiler control thermostat, it should always be set to a higher temperature than that of the cylinder thermostat. In most boilers, a single boiler thermostat controls the temperature of water sent to both the cylinder and radiators, although in some there are two separate boiler thermostats.

3. What is a programmer?

Programmers allow you to set 'On' and 'Off' time periods. Some models switch the central heating and domestic hot water on and off at the same time, while others allow the domestic hot water and heating to come on and go off at different times.

Heating controls: simple explanations for householders

Set the 'On' and 'Off' time periods to suit your own lifestyle. On some programmers you must also set whether you want the heating and hot water to run continuously, run under the chosen 'On' and 'Off' heating periods, or be permanently off.

The time on the programmer must be correct. Some types have to be adjusted in spring and autumn at the changes between Greenwich Mean Time (GMT) and British Summer Time (BST).

You may be able to temporarily adjust the heating programme, for example, 'Override', 'Advance' or 'Boost'. These are explained in the manufacturer's instructions.

The heating will not work if the room thermostat has switched the heating off. And, if you have a hot-water cylinder, the water heating will not work if the cylinder thermostat detects that the hot water has reached the correct temperature.

4. What is a programmable room thermostat?

A programmable room thermostat is both a programmer and a room thermostat. A programmer allows you to set 'On' and 'Off' time periods to suit your own lifestyle. A room thermostat works by sensing the air temperature, switching on the heating when the air temperature falls below the thermostat setting, and switching it off once this set temperature has been reached.

So, a programmable room thermostat lets you choose what times you want the heating to be on, and what temperature it should reach while it is on. It will allow you to select different temperatures in your home at different times of the day (and days of the week) to meet your particular needs.

Turning a programmable room thermostat to a higher setting will not make the room heat up any faster. How quickly the room heats up depends on the design of the heating system, for example, the size of boiler and radiators. Neither does the setting affect how quickly the room cools down. Turning a programmable room thermostat to a lower setting will result in the room being controlled at a lower temperature, and saves energy.

The way to set and use your programmable room thermostat is to find the lowest temperature settings that you are comfortable with at the different times you have chosen, and then leave it alone to do its job. The best way to do this is to set low temperatures first, say 18°C, and then turn them up by one degree each day until you are comfortable with the temperatures. You won't have to adjust the thermostat further. Any adjustments above these settings will waste energy and cost you more money.

If your heating system is a boiler with radiators, there will usually be only one programmable room thermostat to control the whole house. But you can have different temperatures in individual rooms by installing thermostatic radiator valves (TRVs) on individual radiators. If you don't have TRVs, you should choose a temperature that is reasonable for the whole house. If you do have TRVs, you can choose a slightly higher setting to make sure that even the coldest room is comfortable, then prevent any overheating in other rooms by adjusting the TRVs.

The time on the programmer must be correct. Some types have to be adjusted in spring and autumn at the changes between GMT and BST.

You may be able to temporarily adjust the heating programme, for example, 'Override', 'Advance' or 'Boost'. These are explained in the manufacturer's instructions.

Programmable room thermostats need a free flow of air to sense the temperature, so they must not be covered by curtains or blocked by furniture. Nearby electric fires, televisions, wall or table lamps may prevent the thermostat from working properly.

5. What is a timeswitch?

A timeswitch is an electrical switch operated by a clock. It allows you to set 'On' and 'Off' time periods for either central heating or hot water. It can be arranged to control both central heating and hot water together, but will turn them both on and off at the same times. If you want to control both central heating and hot water and turn them on and off at different times, you should have a programmer instead of a timeswitch.

Heating controls: simple explanations for householders

Set the 'On' and 'Off' time periods to suit your own lifestyle. On some timeswitches you can choose whether you want the system to run continuously, run under the chosen 'On' and 'Off' periods, or be permanently off. You may also be able to adjust the on and off timing temporarily, e.g. 'Override' or 'Advance'. These are explained in the manufacturer's instructions.

The clock in the timeswitch must be set to the correct time. Some types have to be adjusted in spring and autumn at the changes between GMT and BST.

The heating system may have other controls that switch it on or off. For example, the room thermostat will switch off the heating when the room has warmed up. And, if you have a hot water cylinder, the cylinder thermostat will switch off the water heating when it detects that the hot water has reached the correct temperature.

6. What is a thermostatic radiator valve (TRV)?

TRVs sense the air temperature around them and regulate the flow of water through the radiator which they are fitted to. They do not control the boiler.

They should be set at a level that gives you the room temperature you want. These settings may have to be different in each room, and you should set the TRVs to suit each room and then leave them to do their job.

Turning a TRV to a higher setting will not make the room heat up any faster. How quickly the room heats up depends on the boiler size and setting, and the radiator size. Turning a TRV to a lower setting will result in the room being controlled at a lower temperature, and saves energy.

TRVs need a free flow of air to sense the temperature, so they must not be covered by curtains or blocked by furniture.

TRVs cannot turn off the boiler when the whole house is warm. To do that, you will need a room thermostat as well. The radiator in the room with the room thermostat should not normally have a TRV, but, if it does, keep the TRV on the maximum setting and adjust the room thermostat as explained with the instructions.

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energy saving trust[®]

Energy Saving Trust 21 Dartmouth Street London SW1H 9BP
Tel 0845 120 7799 Fax 0845 120 7789
bestpractice@est.org.uk www.energysavingtrust.org.uk/housing

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