Central heating systems
The idea of being able to heat all the rooms in a house was first contemplated in the 1950s. Up until then, which room was heated depended on which room was going to be used. The normal heat source was an open coal fire.

Over many years, central heating has developed into an efficient and sophisticated system that allows full control to suit individual lifestyles. This chapter looks at the requirements for central heating, from the beginnings of home heating to modern systems. In particular, it details the different pipework layouts and controls used for each type of system.

UNDERSTAND THE TYPES OF DOMESTIC CENTRAL HEATING SYSTEMS INSTALLED IN DOMESTIC DWELLINGS

Having central heating in dwellings is now considered part of normal life. However, a few decades ago it would have been considered a luxury.

State the purpose of central heating systems

The purpose of central heating is to:

- provide thermal comfort inside the building or dwelling
- be economical to operate and ensure maximum efficiency.

A newly installed central heating system must meet all the requirements for efficiency as set out in British Standard BS EN 14336:2004 Heating systems in buildings: Installation and commissioning of water based heating systems. This covers the installation, commissioning and testing of modern systems to ensure that they are working as efficiently as possible and that they maximise energy usage.

A modern, efficiently installed central heating system provides many benefits:

- Warmth will be provided throughout the dwelling.
- It allows us to make full use of all the rooms in a building or dwelling.
- A modern central heating system is fully controllable using programmers and thermostats.
- It helps prevent black mould growth and reduces condensation.
- It can help alleviate health problems such as asthma and bronchitis.

Identify the principle pipework systems

Gravity systems

Gravity heating systems work by having the pipework at the correct fall to aid circulation. Full-gravity systems are no longer installed, but you might come across them during maintenance work in older buildings such as village halls. They were sometimes referred to in domestic properties as background heating. One radiator, for example in the bathroom, was fed...
from the primary flow and return pipe from the boiler. Flow and return pipework to the radiator was usually 22 mm diameter.

**Pumped heating with gravity hot water systems (semi-gravity)**
These can be either one-pipe or two-pipe systems.

**One-pipe system**
This works using a one-pipe run (a complete ring of pipework) with a flow and return from the boiler (see Figure 8.01). The disadvantages of this system tend to outweigh the advantages, so they are no longer installed in domestic properties (see Table 8.01). However, as with full-gravity systems, you may come across them in older properties.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower installation cost compared to two-pipe system</td>
<td>The heat emitters (radiators) on the system pass cooler water back into the circuit, meaning that the emitters at the end of the system are cooler.</td>
</tr>
<tr>
<td>Quicker to install</td>
<td>The pump only forces water around the main circuit and not directly through the radiators. This means it is important to select radiators that allow minimum resistance to the flow of water.</td>
</tr>
<tr>
<td>Lower maintenance costs</td>
<td>The ‘flow’ side of the heat emitter (radiator) is usually installed at high level to improve circulation, creating additional unsightly pipework.</td>
</tr>
</tbody>
</table>

Table 8.01: Advantages and disadvantages of a one-pipe system

**Remember**
Gravity systems were never really suitable for domestic properties because of the excessively large-diameter pipes that were required to get only the smallest amounts of heat to the radiators.

**Key term**
*Heat emitter* – a device in a heating system that heats up the space it is placed in (see pages 324–327).

**Did you know?**
Heat emitters are commonly called radiators. However, this is technically incorrect as a heat emitter (radiator) only gives off about 15 per cent radiated heat.
The one-pipe system features an anti-gravity valve to prevent the unwanted circulation of heated water by gravity when the central heating pump is not activated (see Figure 8.02).

Careful balancing and positioning of the radiators is important.

- For a given heat requirement in a room, the radiators at the end of the circuit must be larger than those at the beginning, due to the cooling effect of mixing return water into the flow pipe.
- To ensure correct operation, radiators must be as close to the pipework ring as possible. If you try to cut a couple of connections 100 mm apart into the pipework and run it for 5 m to the radiator, it will not work. The full ring has to be extended to run under the radiator with short tail connections onto it.

Two-pipe system

This system was particularly popular in the 1970s, but is no longer permitted on new properties (other than with solid fuel boilers) unless
additional controls are installed. This type of system no longer meets the requirements of the Building Regulations for extension or boiler replacements to existing oil- or gas-fired systems.

The two-pipe system is the most common method of feeding radiator circuits. Water is pumped around both the circuit and the radiators. This improves the speed at which radiators heat up. The system can be balanced easily by adjusting the **lockshield valve** on each radiator. See page 331 later in this chapter for more on lockshield valves.

**Fully pumped system**

In this system, the hot water and the heating circuits are operated completely by the pump. Because there is no requirement for gravity circulation, the boiler can be sited above the height of the cylinder, giving more design options (see Figure 8.04).

Installations are controlled by **motorised valves**. There are a number of system designs incorporating two-port zone valves or three-port valves (two-position and mid-position) that meet the requirements of the Building Regulations Approved Document L1. Motorised valves are covered later in this chapter (see page 335).

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**Key terms**

**Lockshield valve** – used to balance the system when it is installed or maintained. It is also used as a service valve and is solely intended for use by the installing or maintenance plumber and not by the consumer.

**Motorised valve** – a valve in a water pipe that can be turned on or off by an electric motor. It is one of the heating controls in a system and a valve can be two- or three-port.

**Remember**

Any new system in a domestic property, other than one using a continuous-burning appliance, should be fully pumped.

---

**Figure 8.04: Fully pumped system**
Chapter 8

Compare the operating performance of principle pipework systems

Table 8.02 compares the main systems discussed on pages 310–313 and summarises their main features.

<table>
<thead>
<tr>
<th>Pipework system</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gravity</strong></td>
<td>- No longer allowed to be installed under Part L of the Building Regulations</td>
</tr>
<tr>
<td></td>
<td>- Low installation cost</td>
</tr>
<tr>
<td></td>
<td>- Very low operating efficiency</td>
</tr>
<tr>
<td></td>
<td>- Poor general performance because it works using natural convection; long heat up times and long cool down times</td>
</tr>
<tr>
<td></td>
<td>- Only used in a few rooms to provide background heat due to low operating temperatures</td>
</tr>
<tr>
<td></td>
<td>- Large-diameter pipework required to ensure adequate flow to the heating surfaces</td>
</tr>
<tr>
<td></td>
<td>- Low maintenance requirements; no external controls, pumps or motorised valves</td>
</tr>
<tr>
<td></td>
<td>- Very limited temperature control – boiler thermostat only</td>
</tr>
<tr>
<td><strong>Semi-gravity</strong></td>
<td>- More expensive to install than gravity systems</td>
</tr>
<tr>
<td></td>
<td>- Increased efficiency as heating temperature now controlled by room thermostat, although hot water temperature still controlled by boiler thermostat</td>
</tr>
<tr>
<td></td>
<td>- Cannot select central heating only as hot water is heated continually by natural convection, which reduces system efficiency</td>
</tr>
<tr>
<td></td>
<td>- Higher maintenance cost because of greater use of mechanical and electric components</td>
</tr>
<tr>
<td></td>
<td>- Increased performance of heating system; faster heating and cool down times and full heating to each room</td>
</tr>
<tr>
<td><strong>Fully pumped</strong></td>
<td>- The most expensive system, but greatly increased efficiency offsets installation cost</td>
</tr>
<tr>
<td></td>
<td>- Separate control of heating and hot water with individual on/off time periods</td>
</tr>
<tr>
<td></td>
<td>- Fast heating and cool down times of heating; fast recovery of hot water using high-efficiency cylinder</td>
</tr>
<tr>
<td></td>
<td>- More maintenance needed because of control valves, thermostats, etc.</td>
</tr>
<tr>
<td></td>
<td>- Boiler can be located higher than the cylinder as all circulation is now pumped</td>
</tr>
<tr>
<td></td>
<td>- Full system interlock to ensure no energy consumption when not in use</td>
</tr>
<tr>
<td></td>
<td>- Zoning possible for areas of irregular use</td>
</tr>
</tbody>
</table>

Table 8.02: Comparison of main central heating pipework systems

Explain the function of the pipework component parts

**Feed and expansion (F&E) cistern**

This is used on all open-vented central heating systems. Its main purpose is to allow water in the system to expand, while the cistern allows the system to be filled.

- The water level should be set low in the cistern when filling the system. The cold feed to the system in an average domestic property is usually 15 mm minimum, and this pipe must not include any valves.

Activity 8.1

Visit the SEDBUK website and look at the efficiency requirements of modern boilers. Why is boiler efficiency so important?

Working practice

A customer has recently moved into a house which was built in the late 1970s. She has contacted you about her central heating system: she has noticed that, during the summer months, the upstairs radiators get quite hot even when the central heating is not on and there is only demand for hot water to be heated.

- How would you explain to the customer what the fault is?
- How would you fix the problem?
This is to ensure that, in the event of overheating, there is a constant supply of cooler water to the system to prevent the dangerous condition of boiling.

- The servicing valve to the system should be located on the cold water inlet pipework to the cistern. If a valve were fitted in the cold feed, it could be closed inadvertently; this could have disastrous consequences if the open vent also became blocked.
- The F&E cistern is located at the highest point in the system, and it must not be affected by the position and head of the circulating pump. To avoid any problems with gravity primaries, a minimum height can be obtained by dividing the maximum head developed by the pump by three.
- In fully pumped systems, the water level in the F&E cistern should be a minimum of 1 m above the pumped primary to the direct hot water storage cylinder.

**Space for expansion of water**

The system volume expands by about 4 per cent when heated, so a system containing 100 litres would expand by 4 litres in volume. Space must be allowed in the F&E cistern to take up the additional volume when heated.

**Float-operated valve**

The float-operated valve in the F&E cistern controls the flow of water into the cistern. It should be set low enough so that there is enough water to cover the 15 mm cold feed to the heating system. However, it must also allow for expansion of water in the system when it heats up. As indicated above, the expansion is 4 per cent of the system volume. In normal domestic installations, an 18-litre F&E cistern is adequate for this purpose.

The float-operated valve also allows cool water to enter the system should the boiler overheat because of thermostat failure. This will help prevent the water in the system from reaching boiling point, which would be very dangerous. Therefore, the cistern and float-operated valve must be able to withstand a temperature of 100°C. There is more on float-operated valves on pages 204–206 of Chapter 5.

**Primary open safety vent**

The purpose of the primary open safety vent is to:

- provide a safety outlet should the system overheat due to component failure
- ensure that the system is kept safely at atmospheric pressure.

The minimum diameter of the safety vent is 22 mm, and the pipe should never be valved. In a fully pumped system, the primary open safety vent should usually rise to a minimum height of 450 mm above the water level in the F&E cistern. This allows for any pressure surge effects created by the pump. The open safety vent also aids the removal of any air that the system might collect, particularly on commissioning or refilling (see Figure 8.05 on page 316).

**Air separator**

The air separator enables the cold feed and vent pipe to be joined closely together in the correct layout to serve the system. The grouping of the connections inside the air separator causes turbulent water flow in the separator, which in turn removes air from the system. This reduces noise in the system and lowers the risk of corrosion.
Figure 8.06 shows a fully pumped system containing an air separator. This is also called a close-coupled method of feed and vent pipe connection, featuring only two pipes connected to the boiler.

Primary open vent rises to 450 mm above cistern – preventing surge effects

Water level in F&E cistern below CWSC

Figure 8.05: Open safety vent to F&E cistern in a fully pumped system

Figure 8.06: Air separator installed in a fully pumped heating system
Gate valve
A gate valve allows equipment to be serviced. When open, there is no restriction through the valve. The valve has a wheelhead attached to the spindle. When the head is turned anticlockwise, the threaded part of the spindle screws into the wedge-shaped gate, raising it towards the head (see Figure 5.24 on page 202). Gate valves are usually found in low-pressure pipelines, such as the cold feed from the cold water storage cistern (CWSC) to the hot water storage cylinder. You may also find them on supplies to shower valves where the shower is fed from low pressure via a CWSC.

Full-bore valve
A full-bore valve provides the same function as a gate valve but is easier to operate. It works in one quick movement by turning the handle a quarter of a turn (see Figure 8.07). A sphere with a hole through it inside the valve, much like a service valve, is turned as the valve opens and closes. Unlike a service valve, in which the bore is reduced considerably by the sphere, the bore of the pipe in a full-bore valve is maintained through the valve, just like a gate valve, and so provides minimal restriction to the water flow.

Drain-off valve
Also called a drain-off tap, this is covered on page 209 of Chapter 5.

Lockshield valve
These are fitted on heat emitters (radiators) and used to balance the system when it is installed or maintained. They are also used as service valves and are solely intended for use by the plumber, rather than the occupier of the building. They are covered in more detail on page 331.

Automatic bypass valve
These are used to make sure water can flow through the boiler to maintain a minimum water flow rate if thermostatic radiator valves (TRVs) or motorised valves close when there is no more demand for heat in the rooms or dwelling. Once set, the bypass valve will open automatically when the system pressure reaches a set point: a head of pressure will build up because of the still-running pump (see Figure 8.08).

Bypass valves reduce system noise and increase pump life by preventing it working against a dead head: The bypass should be installed between the flow and return. The valve has a direction arrow on it and should be installed with that arrow in the direction of the flow. If a higher capacity is required for large installations, two or more valves can be installed in parallel.

Key term
Dead head – a situation in which the pump is running but all heating controls are closed, preventing the flow of water around the heating circuit. This can damage the pump impeller and lead to pump failure.
Chapter 8

Thermostatic radiator valve

Thermostatic radiator valves (TRVs) are a cost-effective way of controlling room temperature. The user adjusts them to a chosen temperature and the valve then works automatically to maintain that temperature. TRVs help lower system running costs by reducing demand on the boiler. This in turn helps the environment by reducing the amount of carbon dioxide (CO₂) released into the atmosphere.

Compare the different types of space heating systems

Central heating can be classed as full, background or selective.

- **A full** heating system heats all habitable rooms to the normal design temperatures of 21°C for the living room and bathrooms and 18°C for all other rooms. This is based on an outside temperature of –1°C.
- **Background** heating also heats the rooms but to lower temperatures.
- **Selective** heating allows a particular area or areas to be heated, usually by some form of control system.

Describe the configuration of space heating systems

The main types of heating systems – gravity and pumped – have been discussed on pages 310–314, so refer back as necessary.

**C and C+ system**

This semi-gravity system uses a two-port valve and provides independent temperature control of both the heating and hot water circuits in a pumped heating and gravity domestic hot water system (see Figure 8.09). The pump and boiler are switched off when space and hot water temperature requirements are met.

![Figure 8.09: Semi-gravity system with two-port valve (simplified for clarity)](image-url)
A zone valve can also be fitted to the heating flow pipe, enabling temperature control of the heating via a room thermostat. These modifications will ensure that the system meets the requirements of Part L of the Building Regulations with minimal cost. However, the best course of action would be to convert the system to fully pumped. TRVs can also be fitted to provide overriding temperature controls in individual rooms. Time control can be managed by either a time switch or a programmer.

**Fully pumped system using a two-position three-port diverter valve (W plan)**

This was one of the first fully pumped systems to be installed in domestic properties, but it is no longer widely used. It is designed to provide independent temperature control of the heating and hot water circuit in fully pumped heating systems. When used with a programmer, this design satisfies the Building Regulations.

The two-position three-port diverter valve is usually installed to give priority to the domestic hot water circuit (see Figure 8.10). That means it can only feed either the hot water or the central heating system at any one time. For this reason it should not be used where there is likely to be a high hot water demand during the winter months. The designed heating room temperature could drop below comfort level when the demand for hot water is high.

**Fully pumped system using three-port mid-position valve (Y plan)**

This type of system is common in new domestic properties and is designed to provide separate time and temperature control of the heating and domestic hot water circuits. To fully meet the requirements of the Building Regulations, time control must be managed via a programmer and TRVs, and an automatic bypass valve must be fitted (where required). The mid-position valve allows hot water and heating circuits to operate together.

*Figure 8.10: Fully pumped system with two-position diverter valve (simplified for clarity)*
Be careful when working on existing systems: the three-port diverter valve and mid-position valve system look similar. However, the three-port valve and timing device are completely different for each system. The mid-position valve has more wires than the diverter valve.

Did you know?
Although common in new properties, the Y plan system is not suitable for floor areas greater than 150 m². For larger areas, the S plan is recommended.

Working practice
Ray qualified as a plumber last year. He now has his own apprentice and needs to explain to her the installation requirements and system operation for a fully pumped system using a two-position diverter valve.
- List all the points Ray needs to cover.
- What other information will Ray need to tell his apprentice?
- What work is the apprentice likely to do?

Fully pumped system using 2 × 2-port valves (S plan)
This type of system is common in new domestic properties, particularly larger ones, and is recommended for floor areas above 150 m². The main reason for this is the limited capacity of a three-port valve installation to satisfy the heat demands of a larger system. The use of the 2 × 2-port valves also gives greater flexibility in system design, with additional valves being added to the system to zone separate parts of the building – for example, the upstairs from the downstairs – so that each area is controlled individually. The system provides separate temperature controls for heating and hot water circuits (see Figure 8.11). The features are similar to those of the other systems described earlier.

Activity 8.2
Think about how your own central heating and hot water system works and try to work out which plan it uses. Even if you have a combination boiler rather than a traditional boiler and cylinder system, it will still fit one of the plans.
Progress check 8.01

1. In open-vented systems, what is the minimum diameter of the open vent pipe? What is the purpose of the open vent?
2. What is the purpose of an air separator in a central heating system?
3. What type of system would use an S plan?
4. A customer’s heating system sometimes cools down when there is a demand for hot water to be heated. What type of motorised valve are you likely to find in this system? What ‘plan’ is this system likely to follow?
5. On some older systems, the circulating pump was fitted in the return pipe back to the boiler. What problem can this cause, particularly as the system ages?

KNOW THE DIFFERENT MATERIALS USED TO INSTALL DOMESTIC CENTRAL HEATING PIPEWORK

Modern plumbers have to work with various materials, so it is vital to the working life and efficiency of systems that they know and understand the application of these materials.

Identify the principle materials used in domestic central heating applications

The main materials you will come across and work with are copper, mild steel and various types of plastic. You can find out more about these and other materials used in domestic central heating applications in Chapter 4: Common plumbing processes.

Describe the use of plastic barrier tube for installing central heating circuits

When installing modern heating systems with plastic pipework, it is important to use barrier tube. This prevents air from permeating (passing through) the wall of the plastic pipe and into the heating system. Air in the system will quickly cause severe corrosion problems. Figure 8.12 shows the construction of plastic barrier pipe used in central heating systems.

The advantages of plastic pipe over more traditional materials such as copper include:

- it does not promote electrolysis
- it has a very smooth bore to help the flow of water through the pipe.

However, it should not be used on the surface (e.g. on skirting boards): because of its high coefficient of expansion it will sag and look unsightly.

Describe the advantages of insulating pipework

Pipe insulation works by trapping air in its enclosed cell-like structure. Trapped, still air is a poor conductor of heat, which makes it ideal for use in insulation. Even cold water contains some heat energy, and it is this energy that pipe insulation keeps in.

Key terms

- Electrolysis (electrolytic action) – describes a flow of electrically charged ions from an anode to a cathode through a medium called electrolyte, usually water. (See Chapter 3, pages 99–100.)
- Coefficient of expansion – the amount a material expands when heated. (See Chapter 3, pages 95–96.)
Insulating pipework has several advantages:

- Water in the pipework will stay warmer for longer. This means that less water will be wasted where there are dead legs in hot water systems. It is also good for the environment, because the energy used to heat the water is being used more efficiently.
- Pipes are less likely to freeze and burst during cold weather, reducing the risk of water damage to the customer’s property.
- It will help to control condensation problems on pipework. This in turn will help to reduce corrosion.
- It will help to control the noise level of water flowing through the pipework.
- It will help to protect the customer from burns if they touch any hot water or heating pipework.

**State types of pipework insulation**

**Polyethylene pipe**

Polyethylene insulation (see Figure 8.13) is often referred to as closed cell or foam pipe insulation and has several advantages:

- It is cost-effective as it is cheaper than nitrile rubber and foil-backed pipe insulation.
- It has a very low density with strong thermal, physical and chemical-resistant properties.
- It is effective over a wide range of temperatures and will prevent heat gain as well as heat loss.
- It can be installed in many different situations as well as domestic ones.
- It can be used with trace heating for areas that could be subject to very low temperatures.

Its disadvantages are that it is less flexible and more rigid than nitrile rubber and does not have strong fire resistance.

**Foil-backed lagging**

Foil-backed pipe fibreglass insulation comes in pre-formed section with a self-adhesive strip down one side for fast and efficient installation. A roll of foil tape is also used to help make joints at corners and where straight sections butt up against each other. It is designed for insulating pipework and equipment operating within a temperature range of about −50°C to 120°C. This makes it ideal for warm, hot and heating services and for cold, chilled and refrigeration services.

**Nitrile rubber**

Nitrile rubber pipe insulation has a fine, closed cell structure and works within a temperature range of around −45°C to 105°C. It is available in a full range of wall thicknesses and bore sizes and has superior thermal conductivity, making it one of the best pipe insulations in its class. Nitrile rubber is particularly suitable for:

- frost protection
- domestic heating
- ground source heat pump applications
- chilled pipework applications.
State bespoke tools used for the installation of domestic central heating systems

The specialist tools and equipment you will need for installing central heating systems are listed below and covered in more detail in Table 4.01 in Chapter 4:

- ½” (13 mm) hexagon radiator valve spanner (see page 124)
- radiator spanner (see page 124)
- adjustable water pump pliers (see page 128)
- radiator vent key (bleed key/air release valve) (see page 124)
- disposable pipe freezing kit (see page 134)
- reusable pipe freezing kit (see page 133).

In addition, you may need a ratcheted radiator valve spanner. This tool fits most radiator valves, nipples, lugs and cistern connectors, and the integral ratchet means that you do not need to remove the tool to turn it. You should always keep the ratchet lightly oiled and be careful not to let the hexagon key slip when you are using the spanner.

UNDERSTAND HEAT EMITTERS AND THEIR COMPONENTS

Heat emitters are the devices used within a heating system to heat up the space they are placed in. There are various types, and they range in style, material, cost and installation.

Identify the European Standard for the manufacture of radiators

BS EN 442

Radiators sold in Europe formerly had to meet standards set by each country’s certification body, such as the BSI or the DIN in Germany. However, in 1996 BS EN 442: Specification for radiators and convectors replaced BS 3528 in the UK. Since then technology has moved on considerably in both manufacturing and testing. As from 1 July 1997 all radiators manufactured in Europe need to conform to the European standard BS EN 442.

Heat output performance is obviously the main requirement for radiators but the new standard covers several other important aspects not previously covered by BS3528 (and covers some more accurately). These are:

- minimum material thickness for all wet surfaces
- a detailed table of manufacturing tolerances
- periodic burst pressure tests to supplement the 100 per cent leak pressure tests
- pre-treatment and paint quality requirements for corrosion protection and resistance to impact damage
- requirements for product marking, labelling and catalogue data.

It is in the area of heat output performance, however, that the new standard has greatest immediate impact.
Define Delta T

Delta T (\(\Delta T\)) is the difference between the mean (average) water temperature in a radiator and the ambient (surrounding) air temperature – so it is the change in temperature:

\[\Delta T = \text{final temperature} - \text{initial temperature}.\]

Under BS EN 442, radiators must be tested with a flow water temperature of 75°C and a return temperature of 65°C, in a test room with a consistent air temperature of 20°C. In addition, the flow and return connections should be connected at the same end, normally referred to as ‘top bottom same end’ (TBSE) (see Figure 8.14).

Identify different heat emitters used in domestic systems and explain their working principles

Heat emitters can be convectors, radiators or underfloor heaters, with variations within each type. This section looks at the most common types of heat emitter for domestic systems and how they work. Chapter 3 covers the scientific principles of heat emission, so refer to pages 96 and 114–116 as necessary.

Cast iron column radiators

Sometimes called hospital radiators, these are mostly found on older installations in buildings such as schools or village halls. However, some are now being installed in domestic properties as ‘designer’ decor (see Figure 8.15).

Panel radiators

Despite the name ‘radiator’, about 85 per cent of heat from radiators is given off by convection. The heat output of a standard panel radiator can be further improved by welding ‘fins’ (heat exchangers) onto the back. These increase the radiator’s surface area as they become part of its heated surface. The design of the fins will also help convection currents to flow.

Types of panel radiator

Radiator design has developed dramatically as manufacturers aim to provide efficient radiators in a variety of styles. Figure 8.17 shows the most common types of steel panel radiator.

Remember

When choosing radiators, you should take note of manufacturers’ fixing positions. It is often said that a radiator should be positioned beneath a window to reduce draughts. Curtains should finish 10 cm above the radiator.
• Manufacturers provide at least four height options, from 300 mm to 700 mm.
• Width measurements are from 400 mm, with increments of 100–200 mm, to a maximum of around 3 m.
• The recommended height from the floor to the base of the radiator is 150 mm (depending on the height of the skirting board). This allows adequate clearance for heat circulation and valve installation.
• Outputs will vary depending on design. You must ensure that the radiator’s output will be sufficient to heat the room.

Figure 8.17: Types of panel radiator

Seamed-top panel radiator
This is currently the most commonly fitted radiator in domestic installations (see Figure 8.18). Top grilles are also available for this radiator.

Compact radiators
These have all the benefits of steel panel radiators, with the addition of ‘factory-fitted’ top grilles and side panels, making them more attractive to the consumer (see Figure 8.19).
Rolled-top radiator
As the popularity of compacts has increased, the market for rolled-top radiators has declined. Some of the production seams from their manufacture can be seen following installation, making them less attractive to the customer (see Figure 8.20).

Combined radiator and towel rail
This design allows towels to be warmed without affecting the convection current from the radiator (see Figure 8.21). These are generally only installed in bathrooms.

Tubular towel rail
Often referred to as ‘designer towel rails’, these are available in a range of designs and colours. They can also be supplied with an electrical element option for use when the heating system is not required. They tend to be mounted vertically on the wall (see Figure 8.22).

Low surface temperature radiators (LSTs)
These were originally designed to conform to health authority requirements, where the surface temperature of radiators was not allowed to exceed 43°C when the system was running at maximum. LSTs are now becoming popular in children’s nurseries, bedrooms and playrooms, and in domestic properties for occupants with disabilities.

Did you know?
The back of a radiator should not be wedged over the skirting board or tightly under the windowsill as this will prevent air circulation across the back panel, reducing the output. Radiator shelves have a similar effect.
Skirting convector heaters
These work on the principle of natural convection; the fins provide a large surface area for heat output. The panel is heated by conduction from the heating pipe (see Figure 8.23). Cool air then passes through it and is heated. This heated air rises and passes from the panel via louvres at the top. Skirting heating is no longer widely used in domestic properties because of the restrictions placed on output from the heater. However, you may still come across it in some older properties.

Fan-assisted convector heaters
These work by forcing cooler air through the heating fins using an electric fan (see Figure 8.24). Therefore, they require connection to the central heating control system. This type includes include kick space heaters, which can be tucked away where space is limited (see Figure 8.25).

Underfloor heating
Whereas radiators throw heat up at head height (which then travels further up to the ceiling only to travel downwards and return as a cold draught), underfloor heating provides a pleasant warmth for feet, body and head. This is because it produces only a very gentle air circulation.
Chapter 8

Working practice

A client asks you to replace a leaking radiator in her heating system. She explains that several radiators have had to be replaced over the last few years. When you drain the system, it is obvious that the problem is corrosion caused by sludge in the system. You explain that the system will require power flushing and the addition of a rust inhibitor on completion. The client says that the system had rust inhibitor added last time the system was drained 12 months ago. She also asks you to look at the float-operated valve in the roof space as the warning pipe often runs water into the back garden of the property.

The system is an open-vented, fully pumped type.

- Explain what the cause of the corrosion problem could be.

Compare the advantages and disadvantages of using underfloor heating

Table 8.03 outlines the main advantages and disadvantages of underfloor heating.
Advantages | Disadvantages
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• Lower energy requirements, which in turn saves on heating bills and CO₂ emissions | • Relatively slow response time
• More attractive than traditional radiator systems: with no radiators on the walls, occupants have more flexibility with decor and furniture position. | • The heat beneath cupboards, for example, can cause the insides to ‘sweat’ and may damage pieces of furniture.
• Even distribution of heat across the entire room | • The type of floor covering must be taken into consideration so that the radiated heat is not severely impeded.
• Work very well with ground source heat pumps and solar thermal panels | • Should not be fitted under floor-mounted units
• Reduces moisture content in the home, which in turn reduces dust mites and other parasites. This can particularly benefit people with allergies or asthma. | • Pipework in the floor is difficult to maintain should a leak or other problem occur.
• Higher system installation costs than standard radiator systems.

Table 8.03: Advantages and disadvantages of underfloor heating

Describe the importance of radiator valves found in domestic installations

The various radiator valves have been covered on pages 317–318.

Explain how radiator valves operate

There is a wide selection of valves available, which are either thermostatic or manual. The Building Regulations require thermostatic radiator valves (TRVs) to be installed on all new systems unless there is another means of controlling an individual room’s temperature. A thermostat and motorised valve may be used, but these are usually too expensive to include in all rooms. You may be required to install manual radiator valves on repair jobs.

Thermostatic radiator valves (TRVs)

It is best practice to use TRVs, as these control the heat output from the radiator by controlling the rate of water flowing through it (see Figures 8.27 and 8.28). All radiators must now have TRVs fitted (except those in rooms with a room thermostat and in bathrooms). However, the system must be fitted with an automatic bypass to prevent the boiler and pump working against a closed system should all the TRVs close down and the water flow rate in the system fall to a low level. The automatic bypass and its positioning in the system is covered on page 317.

Working practice

A customer has asked you to look at one of their radiator valves. Every time the valve is turned off, water appears and drips from underneath the plastic wheel head. The only way the customer can stop the dripping is by leaving the valve turned on.
• What would cause this to happen?
• What would you do to solve the problem?

Figure 8.27: Thermostatic radiator valve
TRVs are fitted with a built-in sensor, which opens and closes the valve in response to room temperature.

Liquid, wax or gas expands into the bellows chamber as the sensor heats up. As the bellows expand, they push the pressure pin down, closing the valve.

The head of the valve has a number of settings to enable a range of room temperatures to be selected (see Figure 8.28).

Sufficient air flow around the valve is important for correct functioning, so that it can measure the correct air temperature. For example, they should not be fitted behind long curtains where the air flow is restricted and the valve could shut off prematurely.

When radiators fitted with TRVs are removed for redecoration, the TRV head should never be relied on to keep the valve shut off. In severe cold weather the thermostatic head could open. This would allow water to flow through the valve, flooding the building. If this happened overnight there could be a lot of damage by the morning. Manufacturers supply TRVs with a manual head, which is removed when the TRV head is to be fitted. You should leave the manual head with the customer so that it can be refitted to allow safe removal of the radiator, as it will shut off the valve.
regardless of the temperature. The automatic bypass must be fitted in accordance with the boiler manufacturer’s instructions.

**Wheelhead radiator valves**

These allow the user to control the temperature of the radiator manually by turning it on or off (see Figure 8.29). A system using these types of valves must include a room thermostat to provide temperature control.

Rotating the plastic ‘wheelhead’ anticlockwise raises the spindle to lift the valve and open the flow to the radiator. However, repeatedly turning the valve on and off can wear out the gland and cause water to leak from under the valve cap. In this case, it might be a simple case of retightening the gland nut; otherwise, the gland packing itself might need replacing if badly worn (see Figure 8.30).

**Lockshield radiator valves**

These are intended to be operated by the plumber rather than the occupier of the building. The plumber will use this valve to isolate the supply if removing the radiator or to balance the system when commissioning. The plastic cap conceals a lockshield head, which can only be operated with a special key or pliers. Figure 8.31 shows a lockshield valve with an added feature: an in-built drain-off facility.
Explain how to hang a radiator

In the days when windows were much less thermally efficient than today, radiators were positioned under them. Cold air from draughty single-glazed windows would be warmed as it passed over the radiator. These days, however, better glazing means that radiators can be sited wherever the customer wants.

The procedure for hanging a radiator is outlined below. Refer to pages 44–45 of Chapter 1 for advice on manual handling.

Hanging a radiator

1. Check the job specification to make sure the radiator is the correct one for the room.
2. Carefully unpack the radiator and inspect it for damage, making sure you have the vent plug, end plug and wall brackets.
3. Mark the centre position of the brackets. Use pencil so the marks can be removed easily afterwards.
4. Find the centre of the wall where the radiator is to be hung. Then lean the radiator against the wall and transfer the positions of the radiator brackets to the wall.
5. Lightly plumb down from these marks, to indicate where the brackets will be.
6. Measure the distance between the bottom of the bracket and the bottom of the radiator, then add this distance to the proposed height from the floor to the bottom of the radiator. (A minimum distance of 150 mm between floor and radiator is recommended, to allow for good air circulation.)
Describe how to bleed a radiator

To bleed (vent) a radiator, you will need a vent key and a piece of cloth or other absorbent material to catch any water that is displaced from the valve.

- Before you begin, make sure the circulating pump is switched off. If the system is already full of water and you are only releasing a little trapped air, then more air may be drawn in if you try to bleed the radiator with the pump running. This will make the problem worse.
- If you have a system or combination boiler, check that there is enough pressure within the system to force out the air. This check can be made by reading the pressure gauge on the boiler: it should be at 1–1.5 bar. The gauge will drop as the air is released, and you will need to top up the system in order to get the gauge back to 1–1.5 bar. Use a filling loop to do this.
- If you have a more traditional open vented system, with the smaller F&E cistern in the loft alongside the main, larger, cistern, there will be enough natural head of pressure to force the air out. In addition, the system water will be topped up automatically via the ball valve as the air is released from the system.
- Hold a piece of cloth immediately under the vent pin and, with your other hand, use the vent key to turn the vent pin. You must never remove the pin completely as it is very small and very difficult to fit back in once the air has been removed and water is coming out.
- When all the air in the radiator has been vented, water will appear at the vent pin. Re-tighten the pin and test the radiator by turning on the heating system and placing your hand on top of the radiator. If the radiator warms up to the very top, you know that all the air has been removed.
UNDERSTAND MECHANICAL CENTRAL HEATING CONTROLS

Vital to the efficiency of any modern central heating installation are the controls used in the system. This set of controls enables the user to operate the system to suit them and their lifestyle and to save on energy usage to reduce carbon emissions. This section looks at how these controls work together to minimise energy wastage and ensure the customer has plenty of heated water at the right temperature.

Describe the function of a domestic circulator pump

Pumps are fairly simple. They consist of an electric motor, which drives a circular fluted wheel called an impeller (Figure 8.33). This ‘accelerates’ the flow of water by centrifugal force. When installed, domestic circulating pumps are fitted with isolation valves to permit service and maintenance. Figures 8.34–8.36 show other types of domestic circulator pump.

It is the pump’s job to circulate water around the central heating (and possibly the hot water) system, ensuring that the water is delivered at the desired quantities throughout the system components. Most pumps have three settings, and manufacturers provide performance data for each, which shows flow rate in litres per second, pressure in kPa and head in metres (m).

The flow rate should not exceed 1 litre per second for small-bore systems and 1.5 litres per second for microbore systems; anything higher can create noise in the system. Most pumps deliver 5 m or 6 m head. This is usually enough to overcome the flow resistance of the whole heating circuit, in particular the ‘index’ radiator circuit, which is the radiator circuit that offers the greatest frictional resistance to the flow of water.

It is good practice to position the pump so that it gives a positive pressure within the circuit. This ensures that air is not drawn into the system through microscopic leaks.

Describe the effects of the circulator pump in relation to feed and vent

The pressures developed in a central heating system vary according to the pump’s position.

- The pressure on the outlet side of the pump is positive, as the water is being accelerated and expelled at a higher pressure from the pump.
- On the inlet side of the pump, the pressure is negative and the water is being drawn into the pump ready to be accelerated out.

Common sense tells us that there must be a point within the system when positive pressure created by the pump changes to negative pressure. This is known as the ‘neutral point’ and differs according to the type of system that is installed. In open-vented systems, it is where the cold feed enters the system. The only part of the system then under negative pressure is between the cold feed and the inlet of the pump.

The pressure developed by the static head from the feed and expansion (F&E) cistern will never vary (hence the term neutral point) provided the rules for...
installation of the F&E and the connection of the cold feed to the system are observed. In sealed systems, the neutral point will be where the expansion vessel connects to the pipework. The pump position is even more critical in a fully pumped system because of its position in relation to the cold feed and vent pipe (see Figure 8.06 on page 316).

State the differences between motorised valves

All motorised valves must provide the correct flow direction and priority to match the system. Diverter valves are used in modern combination boilers. When a hot tap is opened, the diverter valve operates to ensure that maximum heat input is given to heating the hot water system instantly and not to the central heating.

The type of valve used will depend on the system design, but the following are available:

- three-port diverter valve
- three-port mid-position valve
- two-port motorised zone valve.

Three-port diverter valve

This controls the flow of water in fully pumped central heating and hot water systems on a selective priority basis, normally for the domestic hot water (see Figure 8.37).

Three-port mid-position valve

This looks very similar to the diverter valve. It is used in fully pumped hot water and central heating systems in conjunction with a room and cylinder thermostat. It provides full temperature control of both the hot water and heating circuits, which can operate independently of each other or both at the same time.

Two-port motorised zone valve

A single-zone valve is used in gravity domestic hot water and a separate one is used to control pumped central heating systems to enable separate temperature control of both the heating and hot water circuits. Motorised valves are also used in fully pumped systems to provide separate control of heating and hot water circuits. They can be used to zone different parts of a building. Figure 8.38 shows a two-port motorised zone valve.

Describe the process to exchange a synchron motor

1. Ensure safe isolation of the motorised valve.
2. Slacken the screw which holds the cover in place and remove the cover.
3. Cut the wires which lead to the motor.

Key term

Synchron motor – synchronous motor. An AC motor where the shaft rotation is synchronised with the frequency of the supply current.
Undo and remove the small screw securing the motor to the valve. Take care not to drop and lose the screw.

Remove and discard the old motor and replace it with the new one.

Use new connectors to reattach the wires, taking care not to leave any of the conductor exposed. Refit the cover and tighten the screw securing the cover in place.

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**Knowledge check**

1. What is the outside design temperature when calculating radiator sizes?
   - a) +1°C
   - b) 0°C
   - c) −1°C
   - d) −2°C

2. If a central heating system forms a continuous loop around the dwelling to supply each radiator, what type of system is it?
   - a) full-gravity
   - b) two-pipe
   - c) one-pipe
   - d) semi-gravity

3. What is the name of the electronic device used to control the room temperature inside a dwelling?
   - a) cylinder thermostat
   - b) thermostatic radiator valve
   - c) boiler thermostat
   - d) room thermostat

4. If the floor area of a dwelling exceeds 150 m², what type of system must be installed?
   - a) two-port zone valve
   - b) three-port diverter valve
   - c) three-port mid-position valve
   - d) semi-gravity with two-port valve

5. By how much will the water in a central heating system expand when it is up to operating temperature?
   - a) 1 per cent
   - b) 2 per cent
   - c) 3 per cent
   - d) 4 per cent

6. What is the minimum diameter of the cold feed from the F&E cistern?
   - a) 8 mm
   - b) 10 mm
   - c) 15 mm
   - d) 22 mm

7. What is the minimum height the F&E cistern should be installed above the primary flow to the cylinder in a fully pumped system?
   - a) 500 mm
   - b) 1 m
   - c) 1.5 m
   - d) 1.75 m

8. With regard to an F&E cistern, how far should the open vent extend above the water level in the cistern?
   - a) 450 mm
   - b) 475 mm
   - c) 500 mm
   - d) 550 mm

9. The pump position in relation to the open vent and cold feed is important in an open vented fully pumped central heating system. What does it prevent?
   - a) air from being drawn in and water from being pumped over
   - b) water from being drawn in and air from being expelled
   - c) cool water from circulating around the system
   - d) the boiler from cycling on and off

10. What type of boiler recycles the flue gases before expelling them to atmosphere?
    - a) regular boiler
    - b) condensing boiler
    - c) system boiler
    - d) combination boiler