WARM WATER UNDERFLOOR HEATING SYSTEMS

Guidance Notes

British Plastics Federation
PIPES GROUP

WARM WATER UNDERFLOOR HEATING SYSTEMS

Introduction

Underfloor heating systems consist of a series of pipes which are integrated into the floor structure and conduct heat to the surface of the floor. The heating pipe is the main component of the system. By using flexible pipes joined to a central manifold, continuous lengths can be installed within the floor structure without jointing. Underfloor heating systems provide an attractive alternative to radiators and other convective heating systems. They can easily be used in all types of modern floor construction. Underfloor heating is widely used in mainland Europe. In the UK, it is frequently used in commercial situations and luxury homes. Its benefits are increasingly accepted in housing developments and self-build applications.

Benefits

Underfloor heating creates an even surface temperature across the entire floor area within the building. Using the floor as the heating element frees wall and floor space for furniture, decorations and other uses. However, in utility rooms and bathrooms where radiators may be desirable (for airing clothes, etc.), they can be incorporated into the system and used in conjunction with the underfloor heating.

Underfloor heating systems are safe and clean. As the floor is large in comparison with a normal wall mounted radiator, the system requires a much lower water temperature to achieve the same room temperature, eliminating the risk of burns and improving operating efficiencies. It reduces wasted heat at levels above head height which reduces running costs. As the systems generally operate with a flow temperature between 40°C to 50°C, the use of a condensing boiler can deliver efficiencies of up to 98%. The heat transfer mechanism is predominantly radiant and does not rely as much on convective air movements, which is common to radiator systems. This reduces the circulation of airborne dust minimising the likelihood of allergic respiratory reactions. Underfloor heating produces a 'warm feet, cold head' heat profile which research has shown to be the ideal for comfort levels.

Underfloor heating systems incorporating flexible pipes are simple to install and can be adapted to all common construction methods. The installation of the system is a 'first fix' operation and can be completed in a single visit. As it is installed at an early stage during new construction, before any finishing stages such as painting, it reduces the risk of damage to walls during the 'second fix'.

Underfloor heating can be combined with Ground Source or Air Source heat pumps to provide an energy efficient system.

Underfloor Heating Components

The manufacturers of underfloor heating systems provide all the components necessary to install the system. The products vary from manufacturer to manufacturer but generally include the following:

Flexible barrier pipe incorporating an oxygen barrier to inhibit oxygen permeation supplied in coils up to 1000m in length in nominal diameters from 10mm to 20mm.

Conduit pipes used to protect pipes as they pass through walls or expansion joints.

Manifolds with up to 12 ports. Often include valves for balancing purposes.

Isolation valves to allow manifold assemblies to be isolated.

Mixing valves used to reduce water temperature where the boiler or heat source is serving more than just the underfloor heating system.

Control packs pre-assembled units incorporating the underfloor heating pump, mixing valves and in some cases the isolating valves.

Room thermostats used to provide zone control (individual room temperature control).

Actuators fitted to the manifold and used to form part of the zone control system.

Temperature gauges to assist with balancing the flow in each heating loop.

Edge insulation used on all external wall edges to limit sideways losses particularly in 'wet' (screeded) installations.

Floor panels for retrofit and new build installations.

Heat spreader plates commonly used to span timber joists in joisted floors.

Pipe cutters

Pipe fixing systems pre-assembled units incorporating the underfloor heating pump, mixing valves and in some cases the isolating valves.

Underfloor Heating Design

DESIGN PRINCIPLES

The primary aim of any floor heating design is to create a comfortable indoor environment by ensuring an even surface temperature across the entire heated floor area. The amount of energy transferred depends upon the floor surface heat transfer coefficient (W/m²K) and the difference between the air and floor temperatures.

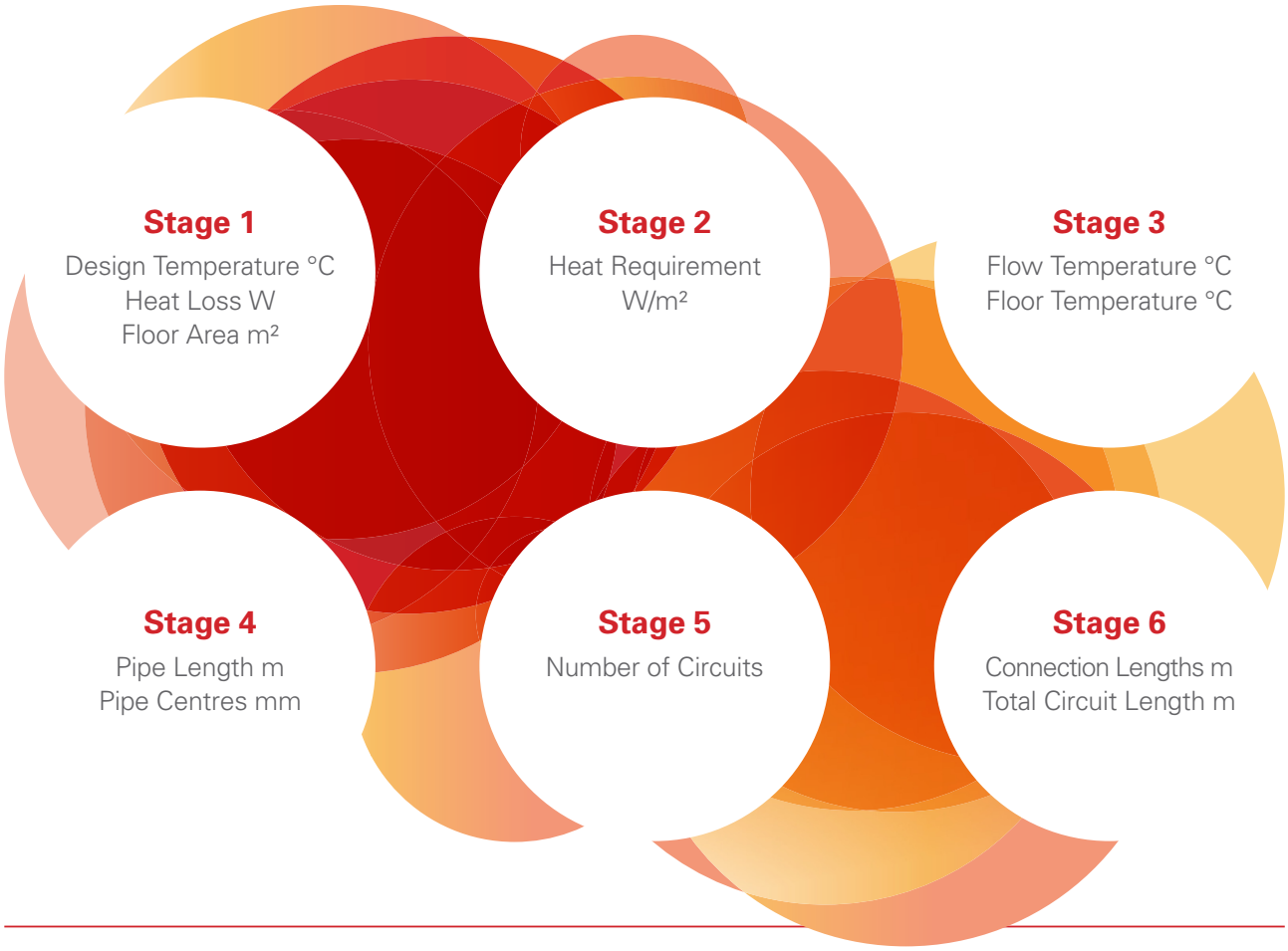
System manufacturers will generally design their systems to the requirements of **BS EN 1264 Parts 1 - 4 Floor Heating Systems and Components,** which defines the design criteria including the maximum floor temperature. The system supplier will specify the temperature drop across each heating loop, the pipe layout pattern and the pipe spacing to suit the installation requirements and to ensure that the floor temperature profile generated is even. The temperature drop across the heating loop is normally designed to be between 5°C and 10°C.

The maximum calculated heat output from a screed floor is limited by the maximum floor surface temperatures, as defined in **BS EN 1264-2 Determination of the thermal output,** and is normally limited to 100 W/m² for a screed floor.

The manufacturers of flexible pipe underfloor heating systems can help with system design and product selection.

DESIGN STAGES

The complete system design comprises a number of stages.



STAGE 1: HEAT LOSS

The heat loss calculation determines how much heat is required to maintain a comfortable temperature in each room. The heat loss for each room is calculated using, for example, the elemental method whereby separate calculations are made for wall loss, window loss, ventilation loss etc. The following information would be required for such a calculation:

- Room dimensions including height.
- Desired room temperature - which depends on the use of rooms, for example a sports hall would require lower temperatures than a nursing home and within a domestic property, bedrooms are usually at a lower temperature than living rooms and bathrooms.
- Outside design temperature. The default outside temperature is set at no higher than -1°C and many heating designers prefer to use -3° C.
- Air changes per hour i.e. 1.5 for rooms in constant use, 2 for kitchens and bathrooms, and 1 for bedrooms.
- Floor coverings or finish – hard surfaces such as tiles etc. are good heat emitters, whereas thick carpets and underlays create a resistance to the passage of heat.
- U values used in the construction of the building - given in Approved Document L1 to the Building Regulations for various construction elements.

STAGE 2: HEAT REQUIREMENT

The heat required for each room is calculated by dividing the total loss by the floor area. This gives the required heat output in Watts per square metre, which is multiplied by the floor surface heat transfer coefficient figure to give a heat input figure. If the heat required is greater than the maximum that can be supplied by the underfloor heating system to be installed, supplementary heating may be required to maintain comfort conditions during the coldest days of the year.

STAGE 3: FLOW TEMPERATURE

The system supplier will calculate the flow temperature required for the heating system to achieve the heat requirement.

STAGE 4: PIPE LENGTHS AND CENTRES

During the design stage, the system supplier will determine the lengths of pipe required for each heating loop and will also specify the pipe centres and layout. Loop lengths are, where possible, normally designed to be of similar lengths to achieve flow balance in the system.

STAGE 5: NUMBER OF CIRCUITS

The number of circuits in an underfloor heating system will depend on the size and layout of the property to be heated.

STAGE 6: CONNECTION LENGTHS

Halls and landings are commonly used as connection areas and due to practical constraints may not have their own heating loop. Connection pipes through these areas and the room in which the manifold is positioned, contribute to the heat requirement of the room. This often means that these areas do not require their own circuit. These rooms are the last to be designed when the number and length of connection pipes to the other rooms is known.

COMPONENT DESIGN

Pumps

All underfloor heating systems require a circulation pump. Its function is to circulate water through the pipe loops independently of any other pumps in the heating system. It is in addition to the primary boiler pump and cannot be used instead of the primary boiler pump. The manufacturer will generally provide data to ensure that the correct pump has been selected to deliver the required pressure and flow rate.

Manifolds

The heating pipes are connected to distribution manifolds. When all rooms and connection areas have been designed, a manifold with the appropriate number of ports can be selected.

It is necessary to balance the loops on each manifold to allow for different loop lengths, heat outputs and floor coverings. Manifolds therefore incorporate balancing valves, so that each heating loop receives the correct flow regardless of the loop length. For example, flow needs throttling in short loops serving small rooms, relative to longer loops serving larger rooms. If the loops are not balanced, the shortest loop will 'steal' all the water from the largest loops, resulting in reduced heating to the largest rooms.

The location of the manifolds in the system should be fixed at the beginning of the design process and should be as central as possible to minimise the lengths of pipe tails and unequal loop lengths.

A mixing device is required prior to the manifold to ensure that the correct water temperature is supplied to the underfloor heating system (see water temperature control). Manifolds generally come with a drain and air vent assembly. Isolation valves are either supplied separately or as part of the manifold. Care should be taken that the manufacturer's instructions are followed when fitting the manifold. In general, the flexible pipes are push fitted into each manifold port after a pipe stiffener has been inserted into the pipe end.

Manifolds can be fixed either directly to a wall or positioned in a manifold box.

Safety devices

Water Temperature Control

When using a standard boiler, the water temperature needs to be controlled to deliver the optimum flow temperature. This is normally achieved by mixing the cooler water returning from the floor coils with the higher temperature water from the boiler.

Most underfloor heating manufacturers provide factory assembled units which include the underfloor heating pump and the water temperature control. These vary in capacity and in detail and the manufacturer should be consulted. It is common to install an overheat thermostat so that in the event the mixing device fails, water in excess of the design temperature is not passed through the pipe loops.

Room Thermostats

To comply with Building Regulations, thermostats are required to control the air temperature and to shut down the heat source when the heating system is satisfied. It may be necessary to provide zone control to meet these requirements. Individual room control is recommended to provide optimal comfort conditions in every room. In this case, each loop of the manifold is fitted with an actuator, which is controlled via the corresponding room thermostat.

Installation

Installation should be carried out in accordance with **BS EN 1264-4 Installation** and the instructions supplied by the manufacturer. The pipe layouts set out in the design must be followed carefully with attention paid to the flow direction.

Underfloor heating systems with flexible pipes are suitable for laying under solid, timber suspended and floating floors. Guidance is provided here on each installation.

SOLID FLOORS

Preparation and insulation

Prior to installation of the underfloor heating systems, the sub floor or slab should be completely cured. The whole floor area must be totally dry and swept clean from mortar residues.

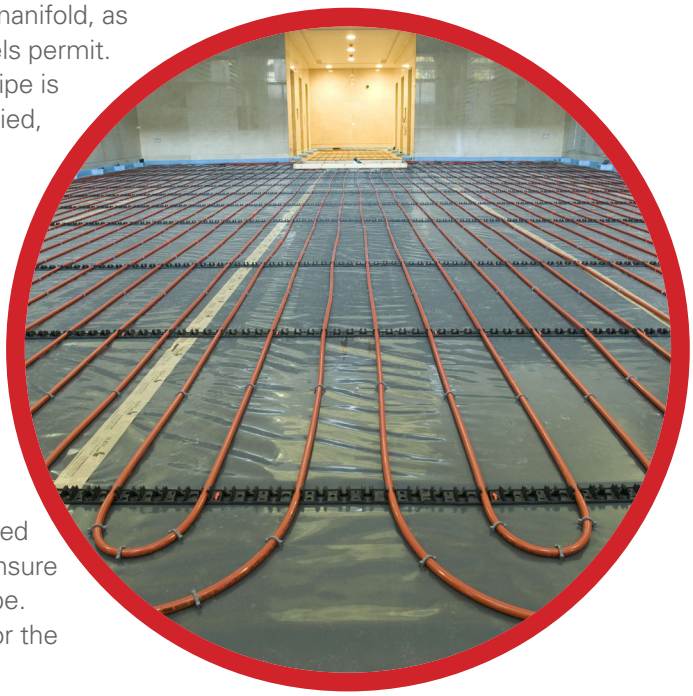
Insulation is then laid. The insulation must conform to the current Building Regulations Part L1. Edge insulation strips (often supplied by the manufacturer of the system) permit the free expansion of the floor screed and need to be installed around all surrounding walls and fixed constructions such as columns and steps. The edge insulation must also be used to separate areas where either the total area exceeds 40 sq. m or where lengths less than 8m exceed a length times width ratio of 1:2.5. Edge insulation is bent at 90° near to the base to form a double-sided self-adhesive strip, which bonds the floor plate to the floor insulation.

When using sub-floor insulation care must be exercised to ensure that screed or concrete cannot bridge between insulation panels. It is advisable therefore, to either tape the joints between the insulation sheets or cover the entire insulation with a polythene sheet. This sheet must not be regarded as the damp-proof membrane.

Pipe laying

The pipe must be installed in accordance with the system manufacturer's instructions. One end of the pipe loop must be connected to the manifold BEFORE the loop is laid. Pipe bend supports are fitted where the pipe turns through 90° from the floor level to the manifold. Some systems recommend the use of floor panels, which are provided as part of the system. These are installed on top of the pre-installed insulation and interlock or overlap at the edges.

Floor panels should not be used at the base of the manifold, as pipes need to be closer together than the floor panels permit. Pipes in this area should be retained by pipe clips. Pipe is installed in accordance with the design details supplied, i.e. pipe spacings, layout pattern and circuit lengths.



Alternatively, the pipe can be laid by clipping or stapling to the insulation, (where bends should be formed using a cold forming bend), or by fixing to a steel grid or plastic clip rail.

The free pipe end is then connected to the manifold. Conduit should be used where the heating pipe passes through the expansion joints, through walls and where the pipe exits the screed to connect to the manifold. The system must be pressure tested before laying the screed and the pressure is maintained and monitored during floor screeding and curing to ensure that the screeding process does not damage the pipe. The manufacturer's literature should be consulted for the recommended testing pressures.

Floor laying

Floor laying should take place as soon as possible after the pipe installation to prevent any accidental damage to the pipe. Most screeds are suitable for underfloor heating systems including sand/cement screeds, fine and heavy duty concrete, anhydrite screeds, polymer modified mixtures, epoxy resin materials and compacted sand. The heating systems do not impart any excess stress to the screed or concrete and, therefore, it is not necessary to provide any additional reinforcement. Screeds must be laid in accordance with the manufacturer's instructions and allowed to cure and dry naturally until the full strength is achieved. When the underfloor heating system is first switched on, the water temperature should be increased slowly over a period of at least seven days.

TIMBER SUSPENDED FLOORS

Installation methods are available for underfloor heating systems which suit both new and existing buildings. Insulation meeting the requirements of the Building Regulations Part L1 is laid between the joists. All other services, such as cables and plumbing, should be installed prior to installation of the heating system.

There are several methods of laying pipes in a suspended floor depending on the type of floor and site restrictions.

OPTION 1 *Notched joists installation from above.*

The voids between the joists are filled with appropriate mineral wool or foam insulation. The pipe is laid between the joists, on top of the insulation, and clipped to each side. As the pipe returns between the next pair of joists, an allowance is made for a radius of 150 mm and the joist notched to allow for the pipe to cross to the next void. The maximum notch size needs to comply with Building Regulations and any local authority requirements.

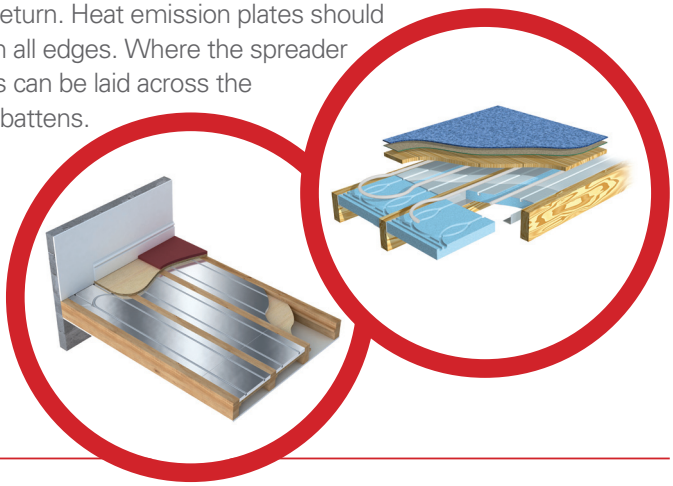
OPTION 2 *Installation from below.*

A pair of parallel holes is drilled through the joist along one side of the room to be heated. The pipes are looped through all the holes and pulled between each pair of joists to the full length of the room. The pipes are then clipped to the sides of the joist or to the underside of the floor (providing the floor will not be lifted at any time).

The voids between the joists are then filled with appropriate mineral wool or foam insulation.

OPTION 3 *Using heat spreader plates.*

Heat spreader plates can be used where it is not possible or desirable to drill or notch the floor joists but is possible to raise the floor height. These are supplied by the manufacturer for use with their system. They are only for heat distribution and are not structural. The voids between the joists are filled with an appropriate mineral wool or foam insulation. Where the joists are at suitable centres, the spreader plates may be installed to span the joist. A gap should be left at the return end for bending the pipe to return. Heat emission plates should be installed so that there is at least a 5mm gap between all edges. Where the spreader plates cannot be laid directly between the joists, battens can be laid across the existing joists and the spreader plates laid between the battens. The pipes are then laid in the spreader plates.



The flow and return ends of each circuit are connected to the manifolds and the system pressure tested in accordance with the manufacturer's instructions before completing the floor.

FLOATING FLOORS

Floating floors can be laid onto any existing base and allow an underfloor heating system to be installed in new and existing buildings. The underfloor heating system is laid using floor panels consisting of insulation panels with pre-grooved pipe slots. The floor panels alone may be sufficient to meet the requirements of the Building Regulations Part L1.

The floor panels are laid on top of the existing timber or solid floor ensuring the panel grooves are aligned.

Heat emission/spreader plates are then laid out in the pre-grooved insulation in the configuration required. These plates ensure an even spread of heat across the floor area. Pipes are then installed. A polyethylene membrane may be used as a moisture barrier if required.

The flow and return ends of each circuit are connected to the manifolds and the system pressure tested in accordance with the manufacturer's instructions.

The floating floor is laid directly onto the completed heating system. Where carpets are fitted care must be taken when fixing grip rods and door plate strips.

BENEFITS OF UNDERFLOOR HEATING

For the Installer

- No previous underfloor heating experience needed
- Helps with compliance to meet Part L Building Regulations
- Single sourcing of materials
- Assured installation outputs and performance
- Faster and easier installation than conventional underfloor heating
- Factory fitted components (pre-assembled products)

For the Householder/Occupier

- More wall space available
- Greater comfort and safety: even warmth, no hot radiators
- Lower running costs and minimal maintenance
- Separate room controls: more control than conventional radiator systems
- Healthier environment with less dust

A list of members who manufacture and supply warm water underfloor heating systems is provided on the BPF Pipes Group website, https://bpfpipesgroup.com/applications/building-services/