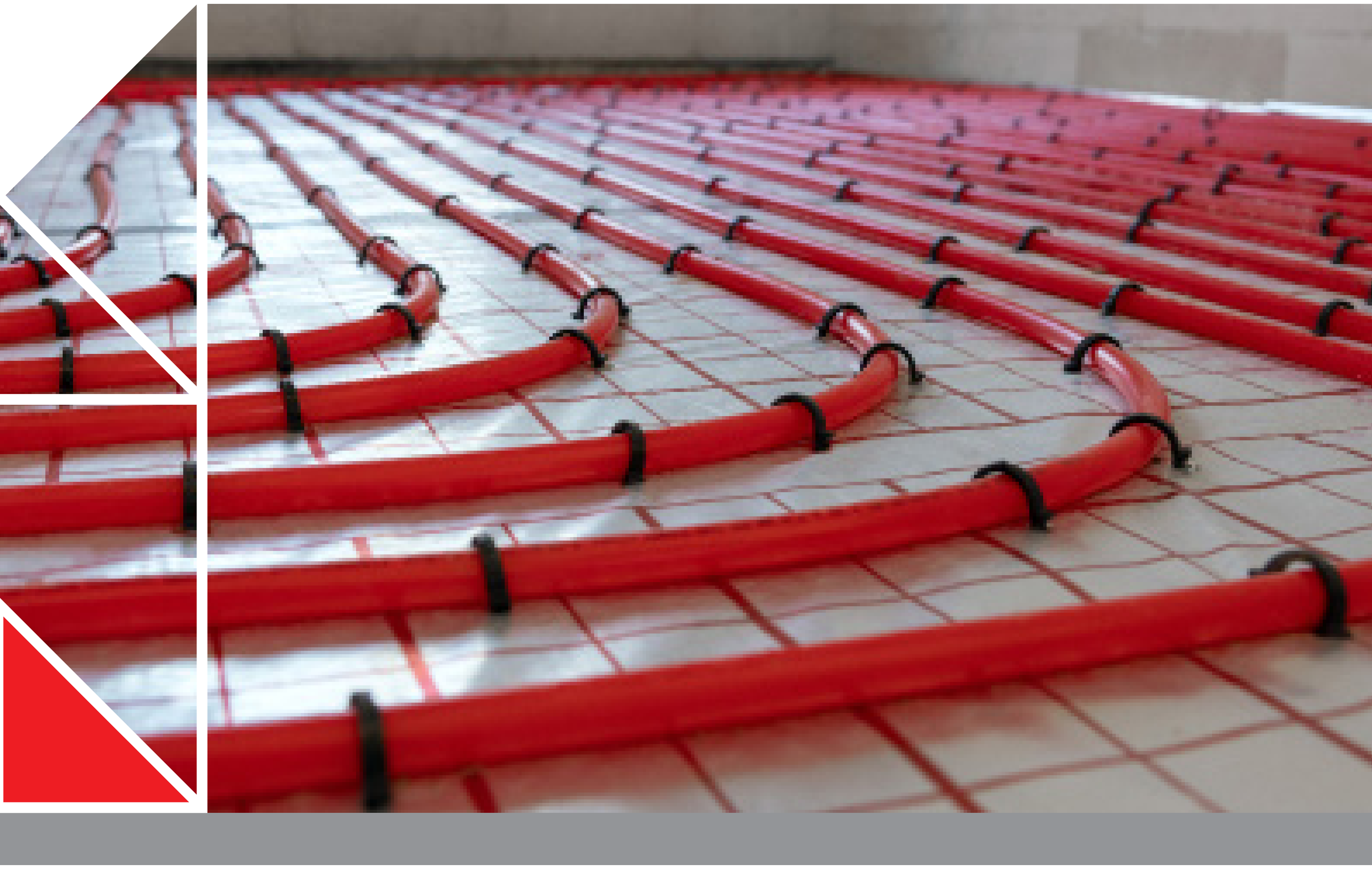
ISSUE 688 BULLETIN



EMBEDDED FLOOR HEATING

January 2024

- Embedded floor heating systems produce a uniform heat over the entire floor area, providing direct radiant comfort from low-temperature heat stored within the slab.
- This bulletin describes the design, installation, commissioning and maintenance requirements of two types of systems: piped hot water (hydronic) and electric heating.
- This bulletin updates and replaces Bulletin 586 of the same name.

1 INTRODUCTION

1.0.1 Floor heating is not a new idea. Hot air or flue gases channelled under the floor were used for heating in Rome and Korea at least 2,000 years ago. In the 1930s, Frank Lloyd Wright piped hot water through the floors of many of his buildings, and post-World War II saw an increased use of floor heating in America. Electric embedded floor heating has been available in New Zealand since the early 1970s and hot water systems from the mid-1980s.

1.0.2 This bulletin outlines the design and installation requirements for hot water and electric floor heating systems that are embedded in a concrete floor or topping screed, either slab on ground (including raft slabs) or suspended. Options for other types of floors are not discussed.

1.0.3 This bulletin updates and replaces Bulletin 586 of the same name.

2 BENEFITS AND LIMITATIONS OF FLOOR HEATING SYSTEMS

2.0.1 Floor heating systems are widely used as effective, efficient primary heat sources but can also be used as a secondary or ambient heat source to provide background heat that can be supplemented by other heating sources. These systems provide space heating by:

- low-temperature radiant heat transfer from the floor, which warms the walls and ceiling of a room and the people and objects within it
- convective heating of the air within the space from contact with the warmed surfaces.

2.0.2 Some benefits of embedded floor heating:

- Heat is produced uniformly over the whole floor.
- The heat source is at the feet so there is a high level of perceived comfort although the actual air temperature may be lower.
- The higher surface temperature of the floor reduces the likelihood of condensation, mildew and mould. Conditions favourable to dust mites are also reduced.
- The self-regulating behaviour of embedded heating using thermal mass means that, as room temperature increases, the heat transfer from the floor decreases. This maintains a stable internal environment and limits the risk of overheating.
- There are no fans to create noise, and the room is draught-free.
- No room space is occupied by vents, ducts or heating panels, and the only visible components are wall thermostats and control panels.
- Hydronic systems can also be used for cooling.
- Wireless and smart home (remote) control options are available.
- Specific design programmes are available that allow room-by-room heat-loss calculations.
- Automated operation adjusts to internal and external temperatures to maximise economy.

2.0.3 Some limitations of embedded floor heating:

- Slow response time when heating a single-pour floor from cold (which can be mitigated by maintaining a low level of background heat rather than turning the system off). Note that systems installed in a topping screed have a faster response time if they are thermally broken from the structural slab.
- An embedded floor heating system must be installed and financed while the house is being built, although the heat source for a hydronic system could be installed at a later stage.
- Care is required during installation and concrete placement. Damage or faults identified after concrete placement may be difficult to rectify.
- Future alterations to walls and fittings are difficult to make, since pipe or cable layout is fixed.
- Location of heavy fittings or fixtures needs to be considered at the design stage of the electric floor heating system as overheating may occur underneath them.
- There may be pump noise in hydronic systems. Where possible, pumps and the associated control panel should be located away from sleeping areas.
- In cold climates, locating all pipework within the thermal envelope is recommended. Where pipework is outside the thermal envelope, anti-freeze needs to be incorporated into the circulating water (heat loss will be greater from the pipes outside the thermal envelope).
- Floor coverings need to be confirmed at the design stage so that their effect on the performance of the heated floor can be allowed for. Carpeting over a heated floor will reduce the heat transfer to the house, but design packages are available that allow for the reduced effectiveness of the heating.
- For systems installed in a structural slab, the supplier may require the use of crack inducers rather than saw cutting the slab to control shrinkage cracking.

3 TYPES OF FLOOR HEATING

3.0.1 There are two types of embedded floor heating:

- Hydronic floor heating systems, where heated water is circulated through continuous piping.
- Electric floor heating systems, which use electrical cables or elements for heating.

3.0.2 Considerations when deciding which option to specify:

- Hydronic systems typically have lower running costs with a range of water heating options available.
- Hydronic systems require annual maintenance by a certified installer.
- Electric systems are generally simpler.
- Electric systems may use cheaper off-peak or night-rate electricity, but this may limit the time that heating is provided to the slab.
- If off-peak electricity is not available, electric systems can be expensive to run as the primary heat source.

3.0.3 Both systems may be embedded in a concrete floor slab or in a topping screed laid over a structural slab.

3.0.4 Pipes or elements are typically laid out in a spiral or S pattern over the whole floor except under internal walls or fixtures such as kitchen and bathroom cabinets. Many variations are possible, but an even floor coverage is important.

4 BUILDING CODE REQUIREMENTS

4.0.1 Other than retirement homes and early childhood centres, there is no specific requirement under the New Zealand Building Code for the provision of heating in domestic buildings. Clauses that are applicable are:

- B2 *Durability*
- G9 *Electricity*
- G10 *Piped services*
- H1 *Energy efficiency*.

4.0.2 Clause H1 cites insulation requirements for the building and the slab. From May 2023, minimum construction R-values for heated floors in Acceptable Solution H1/AS1 Table 2.1.2.2A are:

- R2.5 for climate zones 1–3
- R2.8 for climate zone 4
- R3.0 for climate zones 5–6.

4.0.3 For slabs with embedded heating systems, compliance with the minimum construction R-values may be demonstrated by one of these methods:

- The schedule method set out in H1/AS1.
- The calculation method set out in H1/AS1 (note that the construction R-value of the slab may not be reduced).
- The modelling method set out in H1/VM1. The proposed floor must, as a minimum, meet the construction R-values of Table 2.1.2.2A.

4.0.4 Where part of a concrete floor is suspended, this portion is treated as an 'other floor' type, in accordance with the schedule method or modelling method.

4.0.5 Where the heating system is installed in a topping screed, the total construction R-value for the slab plus topping screed must meet the requirements of H1/AS1 Table 2.1.2.2A. Confirmation with the relevant building consent authority (BCA) is recommended at the design stage, as this situation may be treated differently by individual BCAs.

4.0.6 In-floor components of the heated floor system are expected to remain serviceable for the life of the building.

5 DESIGN

5.1 SLAB DESIGN

5.1.1 The concrete floor slab accommodating an embedded floor heating system must be in accordance with an Acceptable Solution or be submitted as an Alternative Solution.

5.1.2 In-slab installation requires a minimum slab thickness of 100 mm with 30–50 mm cover to the heating elements. Heating elements are tied to the reinforcing mesh. Design considerations include:

- to maintain the seismic performance of the slab, slab thickness may need to be increased to allow for the thickness of the heating elements
- concrete placement and control joint cutting risk damage and displacement of the pipes or cables
- to achieve the required construction R-value, full underslab and slab edge insulation will be required.

5.1.3 Design of in-slab heating for raft slabs will depend on the particular slab system. Full underslab and slab edge insulation is likely to be required. Generally, heating pipes or electric cables are fixed to the slab reinforcing. Ensure that the required minimum cover is specified. Minimum slab thickness varies and is specified by the engineer or slab system provider. For polystyrene pod slab systems, heating pipes may be stapled to the polystyrene – minimum slab thickness is 100 mm.

5.1.4 Topping screed options include:

- vapour barrier and XPS sheet insulation installed on top of the structural slab with pipes clipped to the insulation
- vapour barrier (if required) and insulating board installed on top of the structural slab with heating cables tied to mesh
- proprietary insulating pads installed on top of the structural slab (over a vapour barrier if required). Heating pipes are pressed into the castellated surface of the pads by walking on them – pipe location is well controlled by the surface design of the pads.

Proprietary insulating pads with heating pipes being 'walked in'.

5.1.5 Composition of topping screed can be:

- dry-mix cement-based screed – 65 mm minimum thickness
- self-levelling liquid screed – typically up to 50 mm thick depending on the product.

5.1.6 Advantages of using a topping screed include:

- underslab and slab edge insulation may not be required for the structural slab in some situations
- the structural slab pour can be completed faster – there is no requirement for placing and testing of heating pipes or cables prior to pouring and possibly no underslab insulation required
- the system can be installed close to completion – with less chance of damage
- there is less thermal mass in the topping screed so there is a faster response time for heating
- it is more cost-effective to operate
- crack inducers or saw cuts are often not required in the screed
- when only specific areas of the slab require heating such as in a bathroom.

5.1.7 Disadvantages of using a topping screed include:
- external wall height is increased by the total thickness of the topping screed and insulation
- bracing element hold-down fixings may need to be increased in length to ensure correct penetration into the structural slab
- exterior door thresholds require design consideration
- construction costs are typically higher.

5.1.8 The location of walls, kitchen and bathroom fitments, fireplaces and other permanent fixtures, slab control joints (if any) and electrical controls (where applicable) should be provided to the heating supplier at design stage.

5.2 DESIGN OF HYDRONIC SYSTEMS

5.2.1 Hydronic systems are closed systems with no direct connection to the domestic water supply. They contain water with additives to make it inert (to avoid corrosion).

5.2.2 Key components of a hydronic heating system (Figure 1):
- The heat source supplies heat to the system by heating the water that is pumped through it.
- Primary pipework carries the heat from the heat source to the manifold(s).
- Manifolds distribute the heat to the underfloor pipe loops.
- Hot water flows through pipe loops that heat the floor.
- The controller switches the heat source on and off and directs the heat to where it is needed to heat the rooms to the desired temperature.
- Circulating pumps, valves and programmable thermostats regulate the flow of hot water through the pipework.
- A separate built-in expansion tank or vessel to accommodate the expansion of water as it heats up and purge valves to eliminate air from the system are required between the heat source and the manifold.
- A solid fuel heat source (pellets or wood), diesel boiler or LPG gas boiler require fuel storage.

5.2.3 Space must be allocated for these items at the design stage, taking into consideration location, noise and access for maintenance.

5.2.4 The manifold should be located near the centre of the building to distribute heated water equally to each zone. The manifold needs to be easily accessible for maintenance. Manifolds may be surface mounted or installed in a recessed cabinet, for example, if situated in a laundry.

5.2.5 The main design parameters for hydronic floor heating systems are:
- pipe spacing and layout (based on heating energy required, flow rates and pressure drops)
- water flow rate and associated temperature difference between supply and return on each circuit.

5.2.6 Pipes laid within a structural slab should:
- have a pipe diameter of 10–25 mm (typically 16 mm)
- have a minimum concrete cover of 30–50 mm
- be at spacings of 100–300 mm depending on heat source and heating load (note that it is difficult to install pipes at 100 mm spacings.)
- not be closer than 200 mm to external walls, internal walls and heavy fixtures.

5.2.7 For pipework embedded in a topping slab, a smaller diameter pipe may be used.

5.2.8 Commonly used plastic for the tubing is cross-linked polyethylene (PEX), polyethylene raised temperature (PE-RT) or a composite pipe (such as PERT-AL-PERT) that has a minimum 50-year durability, is leak resistant, non-toxic and flexible, withstands high temperatures and is not affected by concrete additive or water conditions. Only pipes meeting recognised standards should be used.

5.2.9 PEX and PE-RT pipes are susceptible to UV damage and must be stored where they are not exposed to sunlight. Similarly, exposed sections of the installed heating system pipes (such as pipe connections to the manifold) must be protected from UV exposure.

5.2.10 In-slab connections must be avoided. Connections to the control panel are made with brass fittings.

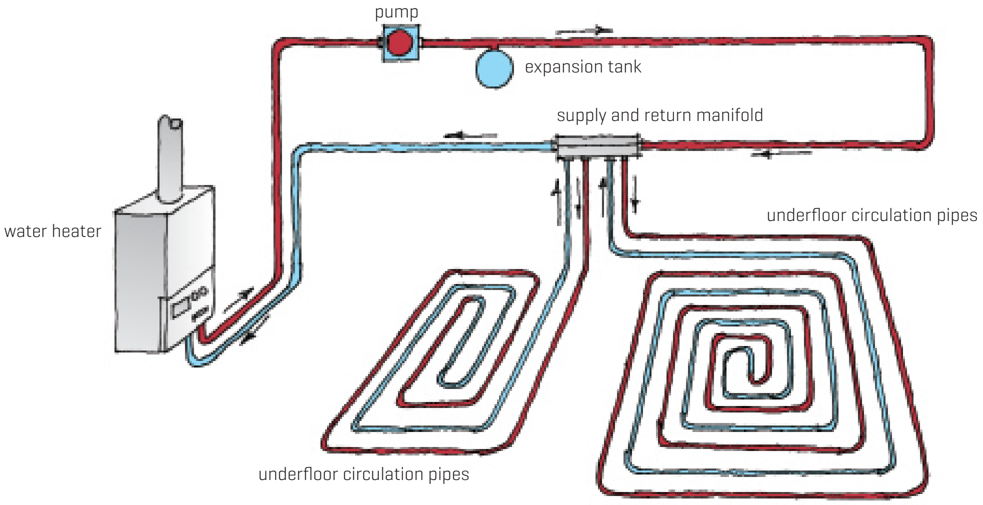


Figure 1. A hydronic radiant floor heating system with two zones.

5.2.11 Hydronic system water temperatures typically range between 35°C and 55°C, with floor surface temperatures of between 20°C and 29°C.

5.2.12 An effective hydronic floor heating system should be designed to the 1% or 2.5% design figures published by NIWA to achieve typical indoor temperatures of 17°C for bedrooms and utility areas and 21°C for living areas and bathrooms.

5.3 WATER HEATING

5.3.1 Some ptions for heating the water in a hydronic floor heating system:

- An electric air-to-water heat pump.
- A geothermal or ground-source heat pump.
- A boiler – electric, wood pellets, solid fuel, gas or diesel.
- Thermal hot water where available.
- A heat exchanger using another heated water source such as a domestic hot water cylinder, which may incorporate a wetback. Controls must be designed to ensure sufficient hot water is retained in the cylinder for household use, which in turn can result in inadequate floor temperatures.
- Solar PV or solar thermal water heating (however, see 5.3.9).
- A combination of the above.

5.3.2 Air-to-water heat pumps use refrigeration cycle technology. By compressing and expanding refrigerant, energy in the form of heat is transferred from a heat reservoir (the outdoor air or the ground) to water in the heating system. Electricity is used to drive the compressor as opposed to creating heat directly. In a well-designed system, every unit of electrical energy put in will yield multiple units of heat energy. However, in cold climates, the system must be selected to ensure it can efficiently heat the water when the outside temperatures are cold. Heat pumps may be noisy in operation. The location of the unit should be carefully considered to avoid nuisance to both occupants and neighbours.

5.3.3 Geothermal or ground-source heat pumps draw heat from the ground. Protected from extremes of heat or cold, the ground a few metres below the surface remains at about 12°C all year round – warmer than the air above it during the winter and cooler than the air in the summer. In a geothermal heating system, fluid (usually a mixture of water and anti-freeze) is pumped through a series of pipes laid in the ground – either horizontally a few metres below the surface or in a vertical borehole. This large volume of low-temperature heat is boosted by a geothermal (ground-source) heat pump to heat a separate smaller volume of fluid, which is then circulated through the floor slab. These systems are expensive to install but are a very efficient way to heat a large house, with higher efficiency than a standard air-to-water heat pump. They are viable in very cold climates such as Central Otago.

5.3.4 Gas, diesel and solid-fuel boilers directly heat the water used in the system. Gas and diesel are carbon-intensive technologies and may be subject to increasing regulation in the future.

5.3.5 Gas boilers use reticulated natural gas or bottled LPG. Natural gas is an economic option where available (North Island only). Due to the time required for initial heating of the floor, bottled gas is only economic for small areas. It is anticipated that natural gas and LPG will continue to be available until the country has transitioned to new low and zero-carbon gases. Boilers are typically installed inside, controlled by a remote programmer or at the boiler.

5.3.6 Oil (diesel) boilers are energy efficient, although running costs depend on the current price of fuel. They are most often used in rural properties. Boilers can be installed inside or outside, with the programmer inside. A fuel storage tank is required outside the house – check with the local authority for specific requirements.

5.3.7 Solid-fuel burners (wood or pellet) can range from conventional combustion burners through to more efficient and higher heat output gasification boilers. Although the energy source is renewable, electricity is required for the control systems. Pellet burners are self-feeding, while wood-fired boilers require more hands-on involvement. A reliable, competitively priced fuel source is important. Requirements for storing, chopping and moving fuel must also be taken into consideration.

5.3.8 Solar collectors heat water via a heat exchanger system but require back-up heating when the sun doesn’t shine and to meet night-time demand. As solar water heating has a fluctuating heat output, it is best used with concrete slab floors with high thermal mass.

5.3.9 Due to the challenges of storage and a predictable energy supply (sunlight), solar thermal water heating and solar PV (where electricity provided by PV panels is used to directly power electrical heating elements or heat pumps) are better suited to domestic hot water heating and are not currently recommended for floor heating.

5.3.10 Solar and some solid fuel systems use large-volume thermal storage (500–1,000 litres) to provide a more continuous source of heated water. Heat exchangers within the thermal store transfer heat to the heating pipes. Domestic hot water can also be heated in this way. Space requirements must be determined at the design stage.

5.4 CIRCUITS IN HYDRONIC SYSTEMS

5.4.1 As the heated water flows through the tubing, it transfers heat to the concrete and cools down. If pipes are too long, heat will flow back from the slab to the water.

5.4.2 Maximum pipe lengths (Table 1) depend on the design pipe diameter, water flow requirements and pump capacity. Water will circulate and return to the heat source more quickly through a shorter circuit, so circuit pipes should be approximately similar lengths to prevent uneven temperatures over the floor. Note that systems designed by a heating specialist may use smaller or longer loops to suit the specific design conditions.

Table 1. Recommended maximum pipe lengths for hydronic floor heating systems.

Pipe diameter (mm)	Maximum pipe length (m)
12	80
15–16	100
20	150
25	200 (for slabs thicker than 100 mm)

5.4.3 One option to ensure a uniform temperature across the heated area uses a spiral from the perimeter to the centre of the room. Water flows into the centre of the spiral and returns through pipes laid between the supply pipes (Figure 2). This layout has the added benefit of requiring only two 180° bends, reducing both the pressure drop and the risk of kinking.

5.5 DESIGN OF ELECTRIC SYSTEMS

5.5.1 Electric floor heating systems consist of electric heating cables or elements that are laid in the floor slab or in a lightweight topping screed. Heat is generated by the cables during off-peak hours, stored in the concrete slab and then released slowly during the day.

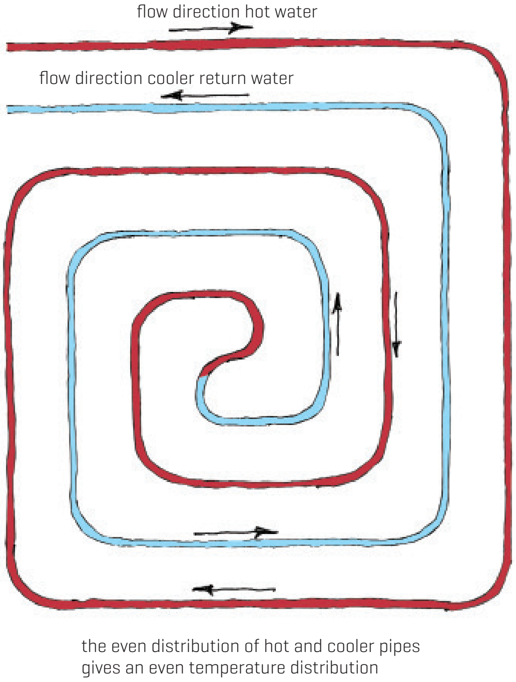


Figure 2. Spiral pipe layout.

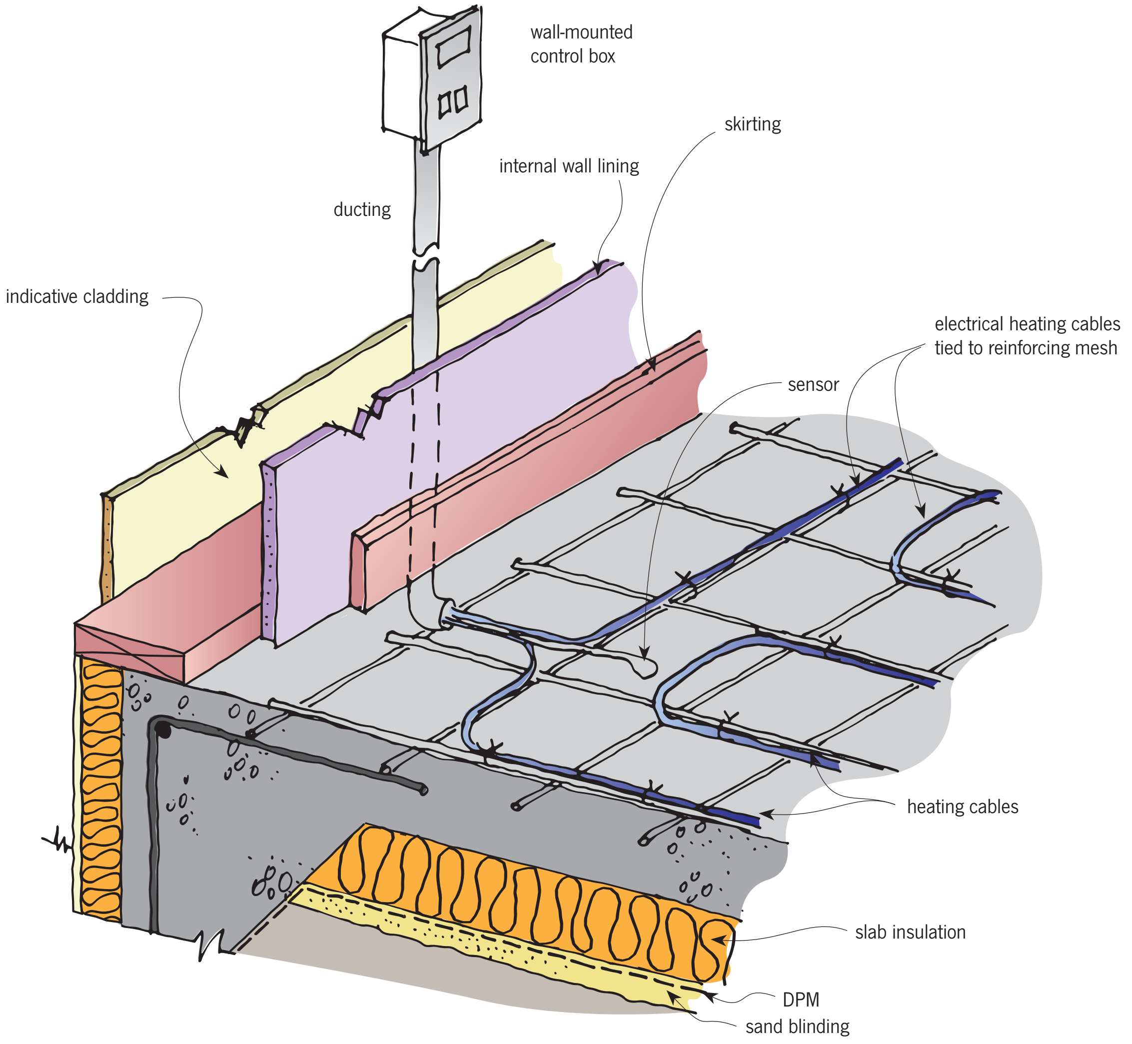


Figure 3. Diagram of electrical floor heating system.

5.5.2 Elements are 6–8 mm diameter cables with a typical design wattage of 130–180 W/m² (depending on heating requirements of the zone). The cables are terminated at each end with 'cold tails' that comprise an earth conductor and a supply conductor connected to a resistance wire that is connected to the mains supply.

5.5.3 For in-slab installation, cables are tied to the slab reinforcing. The slab must be fully insulated.

5.5.4 When installed in a topping screed, the heating cables are tied to lightweight mesh laid over a layer of insulation.

5.5.5 Cables are laid 25–75 mm below the concrete surface and typically spaced at 100–300 mm centres. They must be laid in a continuous length.

5.5.6 No space is required for pumps, tanks or manifolds.

5.5.7 Electric embedded floor heating systems are a good option for areas up to 50 m² and building additions where extending an existing heating system is impractical.

5.5.8 Electric embedded floor heating systems can be zoned into smaller areas than hydronic systems, giving flexibility in use as the areas operate only when required.

6 TEMPERATURE CONTROL

6.1 ZONES

6.1.1 A zone is an area controlled by a thermostat, enabling heating times and/or temperatures to be set differently in different parts of the building. For hydronic systems, adjustable valves on each circuit allow water flow and therefore temperature to be controlled at the manifold.

6.1.2 Every zone should have its own room thermostat.

6.1.3 Separate zones may be considered for areas that are infrequently used or have different heating requirements. For example, a bedroom may be required to be at a lower temperature than the living spaces or a sunroom may heat up more during the daytime, requiring independent zones.

6.1.4 Areas may also be divided into perimeter zones and occupied zones. Perimeter zones with a higher heat output (80–100 W/m²) can be used to provide more even heating in spaces with large areas of glazing or three or more external walls.

6.1.5 The heat load requirement is determined by zone area, insulation values of building elements, orientation of the space, location of the building and local climate.

6.1.6 The heat load for the zone is affected by water temperature, pipe spacing (hydronic systems) or element spacing (electric systems) as well as the thermal resistance of any overlying material.

6.2 TEMPERATURE SENSORS

6.2.1 Temperature can be regulated by an embedded floor sensor, an air temperature sensor or both.

6.2.2 An embedded floor sensor (see Figure 3) can:

- measure the floor temperature and maintain it at a comfortable and safe level
- limit heat input if the floor slab is subject to solar gain
- maintain minimum floor slab temperature.

6.2.3 To prevent damage during concrete placing and enable replacement if required in the future, recommended practice is to install embedded sensors in a conduit (16 mm underfloor pipe is suitable). Seal the end of the conduit that is in the slab with tape to prevent concrete entering. If the floor sensor is for a screed floor, the conduit will need to be cut into the underscreed insulation.

7 INSTALLATION OF THE EMBEDDED HEATING SYSTEM

7.0.1 All systems should be installed by certified installers.

7.1 HYDRONIC SYSTEMS

7.1.1 Pipes are typically laid into the slab or topping slab in a continuous length for each zone. Pipes must not cross each other when the circuits are laid.

7.1.2 Where an in-floor pipe connection is unavoidable (such as for damage repair), the joint must be carefully wrapped with suitable tape to allow for any thermal expansion and to protect the joint from possible in-floor corrosion.

7.1.3 A uPVC sleeve must be fitted where the pipework crosses slab control or cold joints.

7.1.4 Concrete cover should be a minimum of 30–50 mm.

7.1.5 Installers require the location of all relevant walls and floor fixtures such as cabinetry before pipes are laid. Usually it is the builder's responsibility to mark these out. Connecting pipework should be run through passageways and doorways. The position of all plumbing and electrical work must also be established before laying the pipework.

7.1.6 Pipes must be pressure tested before concrete is placed and remain pressurised to 600 kPa during the concrete placement. Pressure testing with air is recommended in areas or seasons where freezing is possible.

7.1.7 Once the floor has been laid, pipe terminations at the control panel location should be protected from damage. Once the building has been closed in, the control panel can be installed and the pipework connected.

7.2 ELECTRIC SYSTEMS

7.2.1 Electric heating cables are tied to the reinforcing mesh with cable ties. If they are spaced to match the reinforcing, they can be directly supported by the reinforcing or additional support bars are required.

7.2.2 Heating cables must not:

- be shortened
- contact or cross each other
- be crossed by a cold tail
- be closer than 100 mm to walls or permanent fixtures
- have a bending radius of less than six times the cable diameter (this must be confirmed with the cable supplier prior to selection).

7.2.3 Cable layout must be as per the specification, and any alterations must be authorised by the supplier or designer.

7.3 SLAB INSULATION (SINGLE-POUR SLAB)

7.3.1 The building envelope must be designed to meet the requirements of clause H1 *Energy efficiency*. For H1 compliance, a heated floor slab must have a minimum construction R-value of R2.5 in climate zones 1–3, R2.8 in climate zone 4 and R3.0 in climate zones 5–6.

7.3.2 Floor slab insulation is essential for reducing heat loss (to the ground or outside air) and maximising the transfer of heat from the slab into internal spaces. This reduces heating costs. Where heating elements are installed in the slab, the insulation will usually need to be continuous beneath the entire slab. Where heating elements are installed in a topping slab or screed, insulation is generally installed beneath and around the edges of the topping.

7.3.3 To calculate the construction R-value for a floor slab, refer to the performance tables in Appendix F of H1/AS1 5th edition. R-values in these tables take into account the thermal resistance of the slab, the thermal conductivity of the soil beneath the slab, the area-to-perimeter ratio of the slab and the width of the external walls of the building. These factors determine the length of the path of least thermal resistance between the interior and exterior environments.

7.3.4 Rigid polystyrene foam sheet is typically used for underslab insulation. It is available in two forms: extruded (XPS) and expanded (EPS) polystyrene. For a given thickness, XPS polystyrene has better thermal performance than EPS but is more expensive.

7.3.5 A damp-proof membrane (in accordance with NZS 3604:2011 *Timber-framed buildings* paragraph 7.5.4) must be placed beneath the underslab insulation and over granular fill/sand blinding.

7.3.6 Up to 80% of the heat loss from a concrete slab on ground occurs around the perimeter and (vertical) edge of the slab. As well as underslab insulation, slab-edge insulation is required to maximise the thermal performance of the slab and therefore the performance of the in-slab heating.

7.3.7 Recommended methods of slab-edge insulation:

- Applying 20–25mm thick XPS to the vertical exterior face of the concrete foundation wall.
- Applying proprietary XPS or PUR perimeter insulation products incorporated into the formwork or applied after the slab is completed.
- Many raft slab systems incorporate slab-edge insulation.

7.3.8 All slab-edge insulation must be protected from the weather (UV light, water) and physical damage, most commonly with a layer of cement or acrylic-based reinforced plaster coated with a high-build or elastomeric type paint finish. Prefinished proprietary products are also available. (Figures 4 and 5).

7.3.9 Slabs constructed using raft systems are regarded as uninsulated under H1/AS1. Thermal performance can be increased by including continuous underslab insulation and/or slab edge insulation. While some systems incorporate these insulation options, others will require specific detailing.

7.3.10 Other situations that will require specific detailing include suspended concrete floor slabs (with unheated space beneath), concrete decks adjoining heated floors and tilt slab wall construction (which is specific engineering design).

7.3.11 Consider insulating floors, walls, windows and roofs to higher levels than the minimum required, as increasing insulation levels will significantly reduce the energy required to heat the building. Wall construction using 140 mm wide bottom plates and framing (rather than 90 mm) with thicker insulation improves the thermal performance even further.

8 INSTALLATION OF FLOOR SLAB

8.0.1 If the slab design calls for shrinkage crack controls, the heating system supplier may require the use of crack inducers rather than saw cuts, unless the heating is installed in a topping screed.

8.0.2 Systems should be tested immediately before concrete placing begins (see 9.1 and 9.2). Keeping water pipes pressurised to 600 kPa during concrete placement maintains the pipe diameter and resists any crushing as the concrete is placed. Flow testing is recommended to confirm the pipe has not been kinked before it is laid. Electric systems may incorporate an alarm to detect damage during concrete placing.

8.1 PLACING CONCRETE

8.1.1 Care must be taken with concrete placement. Pumping rather than barrowing is preferred, as tipping concrete from barrows is more likely to displace or damage pipes or cables.

8.1.2 Concrete should be laid within 2–3 days of pipe installation.

8.1.3 Concrete must be well packed around cables and pipes. Voids can reduce the efficiency of the system and may cause failure of electric cables.

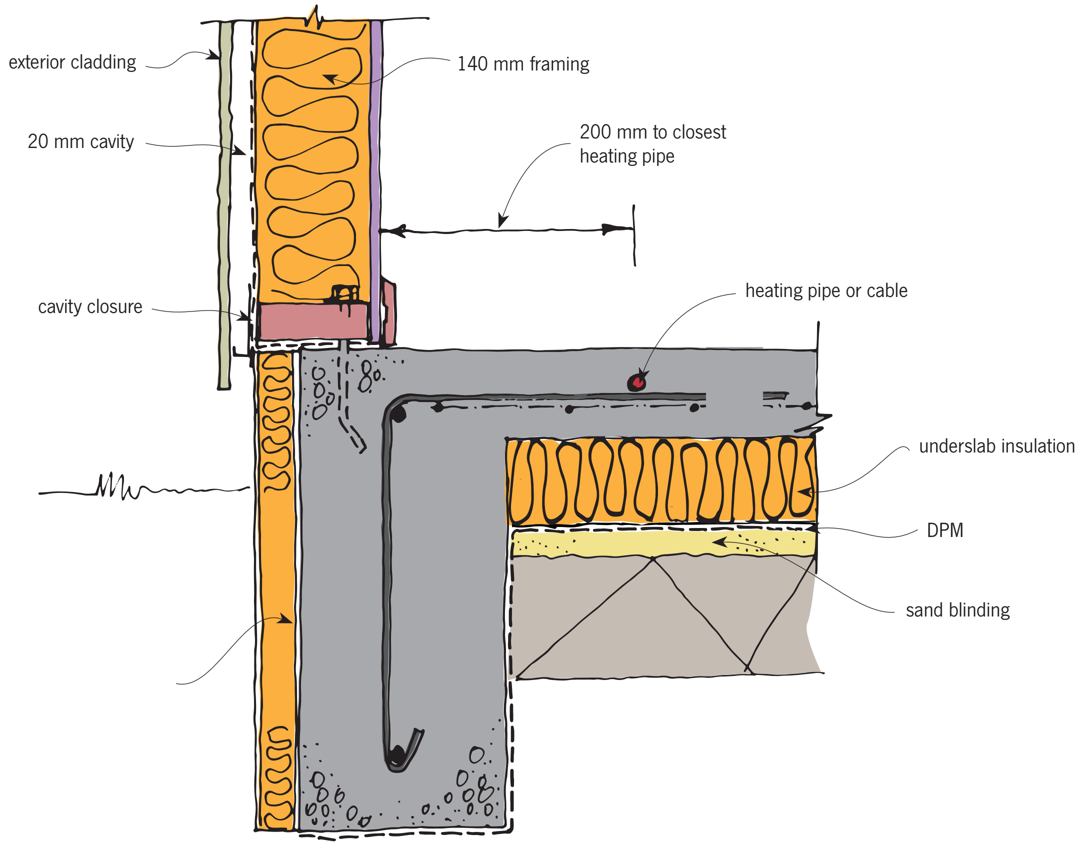


Figure 4. Insulation applied to exterior face of foundation wall with protective plaster or tile finish for cavity construction and 140 mm or wider framing.

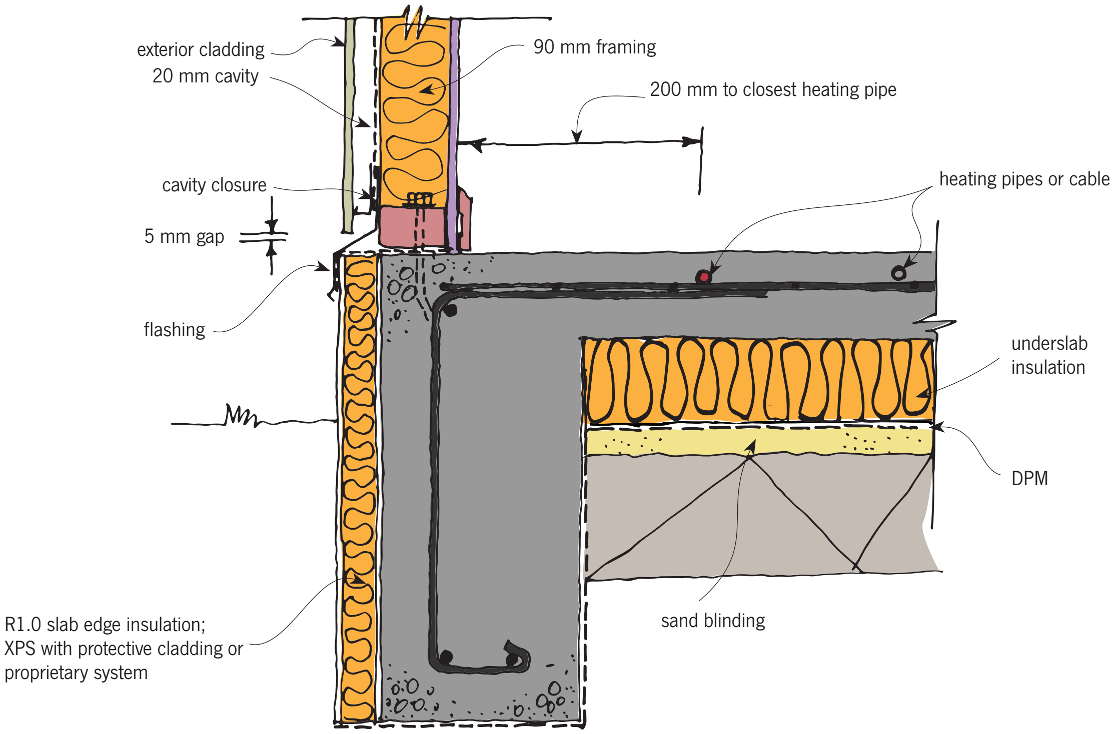


Figure 5. Alternative detail of insulation applied to exterior face of foundation wall with protective plaster or tile finish. Step flashing protects insulation.

8.1.4 Compaction of concrete should be done using a vibrating screed rather than poker head vibrators, which may displace or damage cables or pipes.

8.1.5 If damage occurs during concreting, the pour must be stopped and the cable or pipe removed for repair. A cold joint will need to be formed and the pour continued after the repair.

8.1.6 Due to the proximity of cables or pipes to the surface, any saw cuts in the slab should be a maximum depth of 20 mm and run parallel to the cables or pipes. Alternatively, pipes and cables can be laid at a greater depth where the cuts are to occur.

8.1.7 An insulated control joint is recommended between heated and unheated areas of the slab (for example, where there is an integral, unheated garage). Design solutions are complex and require specific engineering design.

8.1.8 Photographs taken at the time of laying pipes or cables are a useful means of advising other trades of their location.

8.1.9 The position of the pipes should be marked on an as-built plan. A copy of this plan should be available so future owners can be aware of the limitations for alterations.

8.2 CURING CONCRETE

8.2.1 Concrete must be properly cured to reduce the risk of cracking. Cracks may occur along the lines of cables or pipes.

8.2.2 The concrete should be left to cure for a minimum of 5–6 weeks before the heating system is commissioned.

9 COMMISSIONING AND OPERATION

9.1 TESTING HYDRONIC SYSTEMS

9.1.1 Pipework must be pressure tested before concrete placement and then again when the concrete has been poured. Alternatively, the pressure can be maintained during the concrete pour. Test pressure should be at least 600 kPa. Hydrostatic operating pressure should be 100–250 kPa.

9.2 TESTING ELECTRIC SYSTEMS

9.2.1 Electric cables must pass testing for insulation and continuity:

- prior to laying out the cables
- after being laid in position and fixed to reinforcing but prior to concrete placement
- after concreting is completed
- after concrete cutting (if required) is completed.

9.3 COMMISSIONING THE SYSTEM

9.3.1 When a floor heating system is used for the first time, the floor temperature must be raised slowly to avoid stress and cracking to the slab due to drying out too quickly. In general, the heating system must not be used to cure the slab, but this is recommended for some screed systems.

9.3.2 A recommendation when commissioning the system is to set the temperature at 15°C for the first week then increase to 20°C in the second and third weeks. Adjustments can be made as required after this time. Other suppliers recommend setting the heating to 5°C greater than the starting floor temperature and increasing by 1°C every 24 hours until the design slab temperature is reached (typically 27–30°C). An alternative is to follow the procedure from the European standard EN 1264 *Water based surface embedded heating and cooling systems:* run at 20–25°C flow temperature for 3 days, then increase by 5°C every 24 hours until the design flow temperature is reached. Maintain design flow temperature for 4 days, then switch the system off.

9.3.3 The floor must be fully dried out before floor coverings such as tiles or vinyl are fixed. Moisture levels should be in accordance with E2/AS1 (a relative humidity reading of less than 75%) or lower if required by the floor adhesive manufacturer.

9.3.4 The homeowner should be supplied with information indicating pipework or cable layout and any pipe joints if present.

9.4 OPERATION

9.4.1 Thermostats may be hard wired or wireless. Options are available to operate the heating remotely by home automation systems (typically through a smartphone via WiFi or Bluetooth.)

9.4.2 Due to the time required to reheat the slab once it has cooled down, it is more practical to operate an in-slab heating system continuously throughout the heating season. It can run at a lower temperature to provide background heat, with the controls set to turn up in colder weather. Heating installed in a topping slab is more responsive (less concrete mass to heat) and could be turned off on warmer days.

10 MAINTENANCE FOR HYDRONIC SYSTEMS

10.0.1 The control panel and above-slab pipework must be readily accessible for maintenance.

10.0.2 Testing and treatment of the fluid should be carried out according to the supplier’s recommendation, typically annually.

10.0.3 Annual maintenance is recommended for air-to-water and ground-source heat pumps.

10.0.4 Boilers require regular service according to the supplier’s recommendation.

10.0.5 Maintenance must be carried out by certified specialists.

11 FLOOR COVERINGS

11.0.1 Floor coverings reduce transmission of heat from the slab and should be selected to minimise resistance to the upward flow of heat. If the floor covering is known at the design stage, the system can be specified accordingly – for example, by locating the heating elements closer to the slab surface or adjusting the design temperature or flow rate. Maximum R-value of floor coverings should not exceed 10% of the slab insulation R-value. The approximate thermal resistances of selected flooring materials are:

- concrete – 0 m²°C/W
- ceramic tiles – 0.017 m²°C/W
- linoleum – 0.021 m²°C/W
- vinyl – 0.022 m²°C/W
- cork tiles – 0.045 m²°C/W
- timber (10 mm hardwood) – 0.095 m²°C/W
- carpet with thin (e.g. rubber) underlay – 0.15 m²°C/W
- carpet with heavy underlay – 0.4 m²°C/W.

11.0.2 Concrete, slate or ceramic tile finishes provide the best heat transmission surfaces.

11.0.3 Vinyl or linoleum without a foam backing can generally be used over a heated floor provided the floor temperature is not more than 28°C. The adhesive must be able to withstand 40°C.

11.0.4 Foam-backed vinyl, cork or timber floor coverings reduce the efficiency of the heating system. If timber flooring is used, it is important to restrict the heat density and temperature of the floor. If necessary, advice should be sought from the heating supplier and floor manufacturer.

11.0.5 Carpet and underlay with high thermal resistance will restrict the heat flow to the space above. If necessary, advice should be sought from the heating supplier and carpet manufacturer.

11.0.6 Floor coverings such as engineered timber or laminate should typically be acclimatised in the space for 1–2 weeks (with the heating running) before installation. Confirm with the flooring supplier before heating the slab.

12 MORE INFORMATION

STANDARDS NEW ZEALAND

NZS 3604:2011 *Timber-framed buildings*

NZS 4214:2006 *Methods of determining the total thermal resistance of parts of buildings*

NZS 4218:2009 *Thermal insulation – Housing and small buildings*

NZS 4246:2016 *Energy efficiency – Installing bulk thermal insulation in residential buildings*

NZS 6110:2007 *Electrical installations – Floor and ceiling heating systems*

Be aware that the latest version of a standard may not necessarily be the version cited in the Building Code.

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Bulletin 672 *Specifying floors under H1* (June 2022)

Bulletin 676 *Complying with H1 – housing, and buildings up to 300 m²* (October 2022)

Bulletin 678 *H1 Calculation method – housing, and buildings up to 300 m²* (October 2022)

Bulletin 684 *Thermal modelling tools for houses* (May 2023)

Bulletin 685 *Insulation of concrete slab-on-ground floors less than 300 m²* (July 2023)

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ISSN 2537-7310 (Online)

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