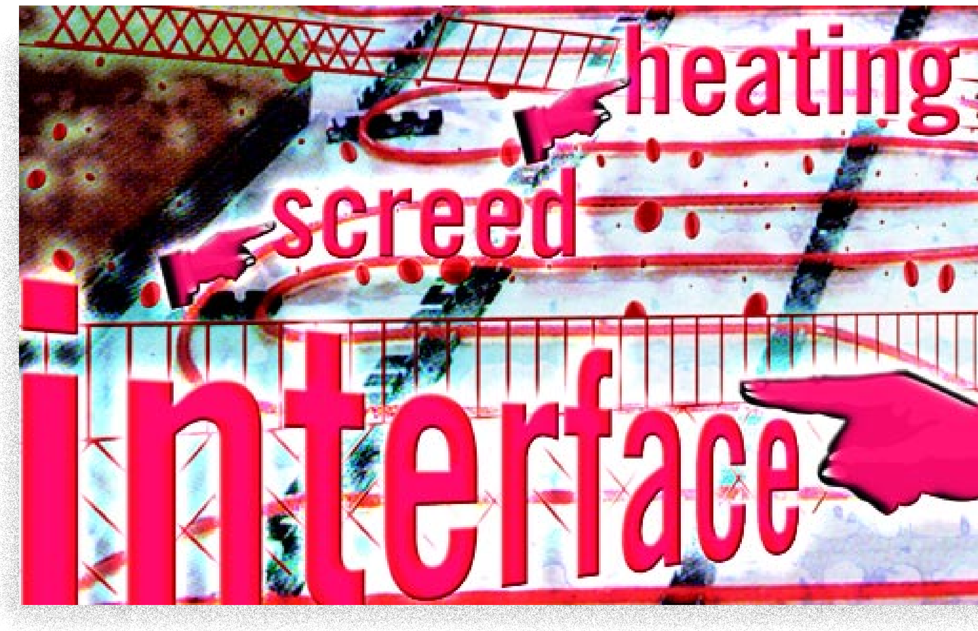
CO-CONSTRUCT

Screeds with Underfloor Heating



Guidance for a defect-free interface

Edited by Roderic Bunn and Dick Roberts

Interface Engineering Publications is a Co-Construct initiative supported by

dti

BSRIA

CONCRETE SOCIETY

What is Co-Construct?

Co-Construct is a network of five leading construction research and information organisations - Concrete Society, BSRIA, CIRIA, TRADA and SCI - who are working together to produce a single point of communication for construction professionals.

BSRIA covers all aspects of mechanical and electrical services in buildings, including heating, air conditioning, and ventilation. Its services to industry include information, collaborative research, consultancy, testing and certification. It also has a worldwide market research and intelligence group, and offers hire calibration and sale of instruments to the industry.

The **Construction Industry Research and Information Association** (CIRIA) works with the construction industry to develop and implement best practice, leading to better performance. CIRIA's independence and wide membership base makes it uniquely placed to bring together all parties with an interest in improving performance.

The Concrete Society is renowned for providing impartial information and technical reports on concrete specification and best practice. The Society operates an independent advisory service and offers networking through its regions and clubs.

The **Steel Construction Institute** (SCI) is an independent, international, member-based organisation with a mission to develop and promote the effective use of steel in construction. SCI specialises in providing advanced internet-based solutions for the construction industry.

TRADA provides timber information, research and consultancy for the construction industry. The fully confidential range of expert services extends from strategic planning and market analysis through to product development, technical advice, training and publications.

For more information on Co-Construct visit www.construction.co.uk.

Screeds with Underfloor Heating

All photographs and illustrations in this publication were provided by BSRIA and The Concrete Society.

Authors: Dick Roberts is with The Concrete Society, and Roderic Bunn is with BSRIA.

Cover Illustration: Jason Harris.

This publication was part-funded by the Department of Trade and Industry under the Partners In Innovation (PII) collaborative research programme. The views expressed in this publication are not necessaily those of the DTI. Final editorial control and publishing responsibility of this publication rested with BSRIA.

©BSRIA/The Concrete Society IEP11/2003 August 2003 ISBN 0 80622 627 1 Printed by The Chameleon Press Ltd

In this guide

Introduction

Underfloor heating is an established technology. However, while the design and operating principles are well known to building services engineers, the finer points of design and installation may not be known by other specialists such as structural engineers, concrete contractors, installers and facilities managers.

Disputes commonly occur on-site where particular items of work were assumed to have been carried out by another party, and as a consequence the work was not completed. With water-based underfloor heating, a common interface problem is between the heating element installation and the screed. If these interface problems are not understood, failures in system performance and/or failure of the screed may occur.

This publication, the first in a series of similar guidance notes called Interface Engineering Publications, has been compiled by BSRIA and The Concrete Society. The objective of this publication is to provide building services engineers and screed specialists with consistent, interlocking advice on how water-based underfloor heating systems and screeds fit together technically, and in relation to the work programme.

This guide largely contains material repackaged from existing BSRIA and Concrete Society guidance. Where possible this has been done word-for-word to avoid giving conflicting or ambiguous guidance. Details of the original publications, relevant European and British standards and other references for further reading are provided at the end of this publication.

All reputable underfloor heating suppliers will provide detailed guidance on the application of their products, and the correct ways to interface those products with screeds and floor coverings. This interface publication should therefore be considered as providing the minimum requirements, with the detailed requirements for the installation being provided by the underfloor heating supplier.

Finally, the design of a floor should be considered a top-down activity, not a bottom-up activity. The choice of floor type will affect the position of joints in the screed and therefore the positioning of the pipework. Flooring type is therefore very much a client briefing issue – not just for reasons of aesthetics, but also for reasons of system performance.

How to use this guide

Advice about the mechanical engineering requirements of underfloor heating systems will be found in blue-tinted boxes. Comments marked by ■ link to screeding sections listed under *also see*. Comments marked by ■ denote a link common to both specialisms.

Advice about the screeding requirements of underfloor heating systems will be found in green-tinted boxes. Comments marked by ■ link to mechanical engineering sections listed under *also see*. Comments marked by ■ denote a link common to both specialisms.

Key mechanical watchpoints

☐ Essential mechanical engineering messages from the guide

Key screeding watchpoints

☐ Essential screeding messages from the guide

Also see

1 **Links** to m&e sections
2 **Links** to screeding sections
3 **Links** to common sections

Standards for screeds and m&e design

Further reading to support this guide

Glossary for terms and definitions

Contents

Client briefing

Full client briefing is crucial if an underfloor heating system is to meet users' needs. Issues that must be addressed include seemingly prosaic but vital topics such as flooring type and anticipated hours of occupation. The response time of underfloor heating will be different for a thick carpet than for clay tiles. Irregular and/or transient occupancy may mean that a radiator-based heating system is more suitable, as faster response may be more important than higher comfort conditions.

Client briefing advice: services

Water-based underfloor heating and cooling systems became common in the early 1980s. They use the entire floor area of a room or a zone, such as a reception or atrium, as the heat emitter (figure 1).

The large floor area means that the mean water temperature can be reduced below that in a radiator-based system, thus providing the required heat output for less energy. The technique gives the beneficial comfort conditions of warm feet and a cool head, an even distribution of heat in the room, and no radiators to impinge on floor area.

Underfloor heating can also be used in a cooling mode in summer. In heating mode, the maximum heating output is around 100 W/m^2, which generally provides adequate space heating for buildings meeting the current *Building Regulations*.

1 Most underfloor heating systems use cross-linked polyethelene (PE-X) pipework. Other materials used include Polybutelene (PB), polypropylene and copper. A metal/plastics multi-layer composite pipe is also available. Plastic pipes are used because of their ease of installation, though copper pipes have the best thermal characteristics.

Designers should advise clients that spaces heated by underfloor systems have certain constraints. For example, if the space is going to be used as a library, the client must ensure that the library bookshelves are not fixed to the floor using shot-fired fixings. For warehouses, underfloor heating can be a very effective method of providing background heating. However, it would be inappropriate to store foodstuffs such as sugar or grain close to the floor as the heat may damage the goods.

Designers should make clear to the client that an underfloor heating system has a slow response time, and that it requires a different control strategy to conventional heating.

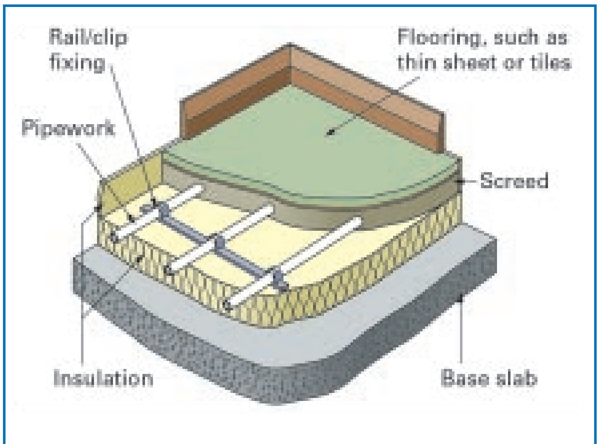


Figure 1: Use this image in briefing documentation to show a typical underfloor heating construction. ©BSRIA.

Client briefing advice: screeds

Underfloor heating pipework is generally laid on top of insulation to prevent downward thermal losses. In turn the insulation is laid on the upper surface of the structural concrete base slab. To protect the pipes in which hot and cold water is circulated, the underfloor heating system is embedded in a sand and cement (fine aggregate) or proprietary cementitious-based levelling or wearing screed (figure 1). A final surface such as a floor covering of thin pvc sheet or tiles must be laid on a levelling screed. Alternatively, a wearing screed can be used without a flooring.

The three most common types of floor construction are:

- ☐ a solid ground floor (figure 1)

2 ☐ a floating floor (figure 2), which should not be confused with a floating screed.

Mechanical engineering issues

Screeding issues

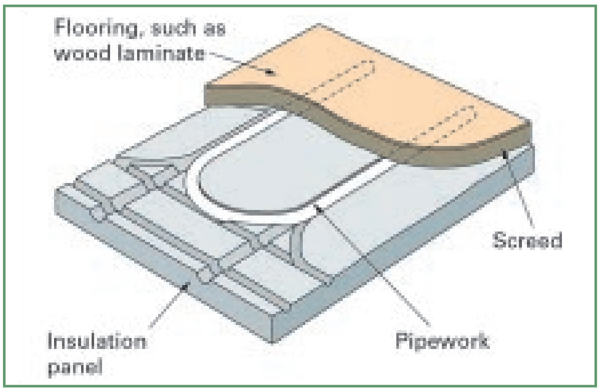


Figure 2: A underfloor heating system using screed over pre-formed insulation panels. ©BSRIA.

3 ☐ a timber suspended/intermediate floor (this type has a sand/cement infill as opposed to a screed – figure 3, page 9).

4 The installation approach is the same for all solid floor types. A layer of insulation on which the pipework is placed is laid on top of the concrete slab to reduce heat loss and to satisfy the *Building Regulations*. A layer of screed is then laid on top of the pipework to act as the heat transfer medium, and to level and strengthen the floor ready for the flooring, such as carpet, tiles or stone. Alternatively, the structural slab, with underfloor heating pipework cast within it, can be laid directly onto the insulation. This does away with the need for a screed.

Floating floor installations are generally constructed by laying a pre-formed high-density polystyrene profiled panel on top of the floor slab. Pipework is laid into the preformed profile, the screed placed, and floor decking – chipboard or finished timber or laminate – is laid on top (figure 2).

Note that the decision to opt for an underfloor heating system may force a change in the height of the building to accommodate the additional depth of the screed.

Key m&e watchpoints

- ☐ Ensure all briefing documents include clear and well annotated diagrams showing the specific nature of the basic system
- ☐ Ensure the client is made fully aware of the specific commissioning and maintenance requirements of all options
- ☐ Discuss how different floor coverings can affect thermal output
- ☐ Ensure guidance is available that testifies to the reliability of the pipework, and of the controls

Key screeding watchpoints

- ☐ Ensure all briefing documents include diagrams showing how a basic underfloor heating system relates to the screed and floor coverings
- ☐ Ensure that the client briefing documents cover the choice of flooring, that the screed type is appropriate to the flooring, and the movement joints are required
- ☐ Discuss how different floor coverings can affect thermal output and the joint layout
- ☐ Ensure the client is made fully aware of the specific commissioning and maintenance requirements of all the options

Also see

1 Figure 8, page 16
2 Screeding installation, page 17
3 Figure 3, page 9
4 Screeding advice, page 10

Standards on page 21

Further reading on page 21

Glossary on page 22

Issues to address during

Outline design

The outline design stage is the point at which the main strategic decisions will be made. The architect will be liasing with the client over a wide range of issues – such as floor layouts, space plans and finishes – that will directly affect the design and construction of the underfloor heating scheme. The services designers, system supplier and specialist contractors need to get access to (and influence) this information. This is also the time where all engineers can make a valuable contribution to a discussion on floor finishes.

Services design information needed

At the outline design stage the building services engineer needs to get access to the following information. The list is not definitive (read BSRIA AG 1/2002 *Design Checks for HVAC* for the full range of design checks), but gives the specific information required to ensure a satisfactory interface with the screeding specialist.

Design inputs

- ☐ Architectural drawings for all zones
- ☐ details of the structural frame
- ☐ space plan and layout
- ☐ floor to ceiling heights
- ☐ position of partitions, glazing and doors
- ☐ details of desired floor finishes
- ☐ space uses
- ☐ hours of occupancy
- ☐ transient occupancy details
- ☐ desired internal design condition
- ☐ target building air leakage rate (in accordance with *Building Regulations Part L2*).

Note that all materials based on cement shrink as they dry; this is aggravated by underfloor heating systems. It is important to design for this movement with the added complication that expansion and contraction movement is associated with heated screeds.

In terms of coverings, carpet tends to be a poor choice of floor covering as it can act as an insulant. Its structure can also be adversely affected by heat over time.

Parquet flooring may be used, but many people advise against it, due to the need for an insulating felt underlay. When an underfloor heating system is run in cooling mode, there is also the risk of condensation forming under the floor covering.

Linoleum (or similar) is considered a good floor covering, as are the various types of rigid and non-rigid floor tile.

Warranty and guarantees

Warranty and guarantees need to be looked at very closely at the outline design stage, as all sorts of claims can be made. The designer needs to look very closely at exactly what is being guaranteed. For example, if a 20 year guarantee is being claimed for the pipe, the engineer needs to know whether that would include the cost of breaking out the floor and reinstating it, as well as the costs for any damage caused by pipework failure.

Where the underfloor heating specialist has designed the complete system, any guarantees should include the complete system, although plant such as pumps and boilers will normally have a shorter guarantee period.

Above: An example of timber flooring used to cover an underfloor heating and cooling installation. The nature of expected pedestrian traffic will directly influence the choice of screed. The heavier the traffic, the stronger the screed.

Mechanical engineering issues

Screeding issues

Screed information needed

At the outline design stage the underfloor heating supplier and screeding specialist need access to the following information. No decision should be taken on the type or thickness of the screed until this information has been gathered and shared with the other partners in the design process.

Design inputs

- ☐ Architectural drawings for all zones
- ☐ details of the structural frame
- ☐ space plan and layout
- ☐ position of partitions, glazing and doors
- ☐ details of desired floor finishes; for example timber, tiles (stone, ceramic or clay), carpet tiles (and their flexibility)
- ☐ space uses
- ☐ nature of pedestrian traffic (heavy or light)
- ☐ the desired internal design conditions.

1 Note that all materials based on cement shrink as they dry; this is aggravated by underfloor heating systems as heated screeds will dry more than non-heated screeds, and will therefore shrink and crack more. It is important to design for this movement and ensure that the drying process is very carefully planned and tightly controlled.

2 Cracks and joints in heated screeds will be live owing to expansion and contraction during system operation.

Flooring choice depends on the context. A thick flooring material (high thermal inertia) is recommended for buildings where there will be no abrupt changes in latent loads.

3 A thin flooring (low inertia) allows a faster response time, which is advantageous in houses, for example, where there can be abrupt changes in loads from people entering and leaving rooms, or from changes in solar loads.

Key m&e watchpoints

- ☐ Read BSRIA AG 1/2002 *Design Checks for HVAC* for the full range of design checks
- ☐ Read BSRIA 30/2003 *Standard Calculations for Building Services* for guidance on calculating thermal requirements
- ☐ Design for the movement of drying cementitious materials, and account for expansion and contraction during system use
- ☐ Gather product information from underfloor heating suppliers and cross-check their system design requirements

Key screeding watchpoints

- ☐ Gather a full set of architectural documentation before deciding on the type or thickness of screed
- ☐ Design for the movement of drying cementitious materials, and that required by the flooring, and account for expansion and contraction during system use
- ☐ Cross-check with the mechanical design engineer on the screeding requirements for all the proposed underfloor heating suppliers
- ☐ Advise on a flooring system that will be able to cope with expansion and contraction of the heated screed

Also see

1 Detailed screed design, page 10
2 Figure 7, page 14
3 Commissioning of screeds, page 18

Standards on page 21

Further reading on page 21

Glossary on page 22

Detailed design: services

The detailed design stage is where all the building services, structural and screeding information must come together in a coherent manner. The building services engineer must share the operational requirements of the underfloor heating system – either wholly or partially supplied by the underfloor heating supplier – with all the specialists involved on the project. Full communication of all system requirements is the key to a successful interface between the building services and the structure.

Mechanical engineering information

The following mechanical design information is required at the detailed design stage (in accordance with BSRIA AG1/2002 *Design Checks for HVAC*).

Design inputs

☐ Zone heating loads
☐ design flow and return temperatures
☐ the internal design condition.

Design outputs

1 ☐ A schedule of zones giving output requirements, flow rates, maximum floor temperatures, and connection and valves a statement of a commissioning strategy
☐ relevant specification clauses.

Design checks

☐ Check that the floor surface temperature is satisfactory for the space
☐ specify adequate insulation under the entire system to reduce casual heat loss to the floor below
☐ specify an insulating strip around the perimeter of concrete floors to reduce cold bridging, as per the supplier's instructions
2 ☐ check that the depth of floor screed is sufficient to accommodate pipework and that it meets the requirements of the relevant *British Standard. BS 8402* recommends not less than 75 mm for a cement/sand screed and 50 mm for a pumpable screed
☐ check that the system suppliers' materials, such as plastic or multilayer pipe, will not be adversely affected by the concrete
☐ check that the chosen flooring is suitable for underfloor heating, such as carpets typically with an insulation value less than 0·15 m^2K/W, adhesives suitable for up to 40°C, and timber with moisture content below 10%.

Design information for contractors

All the contractors involved in an underfloor heating installation need to understand the basic principles of the technology in order to integrate it properly and efficiently into the overall construction process.

3 The main contractor needs to avoid damage to the pipework by arranging for the screed to be laid as soon as possible after the pipework is installed and commissioned.

4 The main contractor should also be informed that the heating must not be used to dry out the structure. A lengthy running up period will be needed to bring the system into use. This needs to be accommodated in the programme and explained in the detailed design documents. It should also be clearly expressed in the instructions to the contractor.

The respective responsibilities of the relevant contractors and the underfloor heating specialist also need to be made clear at the tender stage, and written into all tender documentation to ensure that tenders can be evaluated on the same value and cost basis.

Insulation details

Insulation is generally applied beneath the circuit pipework to stop downward heat loss in excess of the maximum permitted loss of 10% as stated in *BS EN 1264-2*.

Three insulating materials are available: expanded polystyrene, extruded polystyrene, and polyurethane. Polyurethane and polystyrene are available in a number of density grades, each providing different levels of mechanical strength and resistance to pressure. For commercial and industrial situations, the heavier grades may be required. This should be discussed with the architect.

Most manufacturers propose expanded

polystyrene as the insulating material, even though polyurethane has a lower thermal conductivity (0·021 W/mK for polyurethane and 0·033 W/mK for expanded polystyrene). Expanded polystyrene is cheaper and has better acoustic properties. The thickness of the insulating layer is generally 20-40 mm. A barrier should be provided over the insulation to prevent moisture and fresh screed materials penetrating the joints between the insulation. This can also act as a secondary vapour barrier.

5 Insulation can be supplied with pre-formed profiles to hold the pipework. This is generally used for floating-floor installations (figure 2). Pipework is laid into the pre-formed profile and the floor decking – chipboard or finished timber or laminate – is laid on top.

Alternatively, flat sheets are used and the pipework secured to the insulation by a clip system. A sand/cement screed is laid over the pipework to a depth of about 75 mm to form a solid floor on which flooring can be placed.

Intermediate/suspended floor construction also uses flat insulation sheeting on which the pipework is secured. Either a sand/cement infill is placed around the pipework or the space between the flooring (timber product supported on floor joists) and insulation left as an air gap. While this provides a degree of thermal mass similar to a solid floor and raises the floor's heat transfer, the implications of the extra weight must be considered (figure 3).

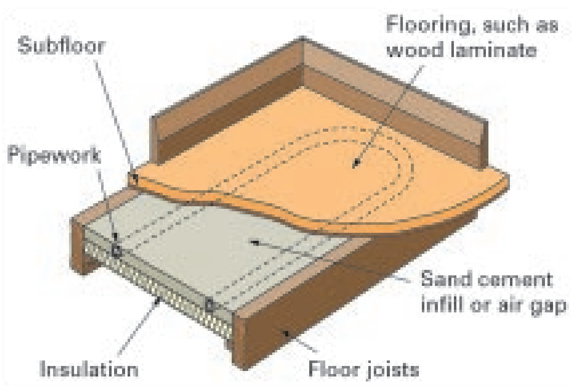


Figure 3: A sand/cement infill, in this case within an intermediate/suspended floor construction. ©BSRIA.

Key m&e watchpoints

- ☐ Check that the temperature of the floor surface is satisfactory
- ☐ Specify adequate insulation under the entire system to reduce casual heat loss to the floor below
- ☐ Specify an insulating strip around the perimeter of concrete floors to reduce cold bridging
- ☐ Check that the depth of floor screed is sufficient to accommodate pipework
- ☐ Check that the heating materials are not adversely affected by the screed
- ☐ Check the type of flooring to see if it requires movement joints as this will affect the layout of the pipework. Reflective cracking in the flooring may otherwise occur

Key screeding watchpoints

- ☐ The main contractor needs to avoid damage to the pipework by ensuring the screed is laid as soon as possible after the pipework is installed and commissioned
- ☐ All persons involved in the contract should be informed that the heating must not be used to dry out the structure
- ☐ A lengthy running up period will be needed to bring the system into use

Also see

1 Commissioning, page 18
2 Finishes, page 19
3 Screed installation, page 17
4 Commissioning, page 19
5 Figure 2, page 5

Standards on page 21

Further reading on page 21

Glossary on page 22

Detailed design: screeding

The detailed design stage is where all the building services, structural and screeding information must come together in a coherent manner. The screeding contractor must share the installation requirements of the screed with the services consultant and the underfloor heating supplier. Full communication of all system requirements is the key to a successful interface – and zero defects – between the structure and the building services.

Screeding design information needed

1 The following screeding design information is required at the detailed design stage. It is vital to agree the consistent use of terminology (such as levelling or wearing screed) with the m&e design engineer and underfloor heating supplier/contractor (Table 1).

Design inputs

The designer should provide and describe the type of flooring, whether it is flexible, or made of tiles, carpet tiles, stone or clay tiles.

The locations of protrusions through the slab and the location of any columns and insets should be identified and described to help define the location of joints. This information should be transferred onto the drawings used by the underfloor heating supplier/sub-contractor, and the m&e consulting engineer.

The screeding specialist should obtain information from the m&e designer about the pipework fixing details - whether it is to the insulation or to the concrete base. The screeding specialist should also obtain information about services access points, such as required for pipework manifolds.

Design outputs

2 In addition to the m&e design outputs, the following design outputs should be provided by the architect/specifier to all partners:

- ☐ Floor construction, thicknesses, joint location and shrinkage characteristics
- ☐ details of the proposed (or choices of) screed material, such as cementitious, calcium sulfate or other proprietary screed
- ☐ the proposed flooring material
- ☐ the screed surface finish in relation to the flooring
- ☐ relevant standards and codes of practice.

Screed materials

A screed is defined as a layer of well-compacted material applied to a structural base or other substrate, finished to a designated level.

There are differences in screed terminology that are commonly used both within the UK and abroad. It is therefore important that any information generated by the design team relating to screeds fully conveys the intended end use.

BS 8204-1: 2002 defines the following screed types:

- ☐ Levelling screed: screed suitably finished to obtain a defined level and to receive the final flooring and
- ☐ wearing screed: screed that serves as a flooring.

3 In this guide the term screed relates to a levelling screed. Additionally, as the majority of heated screeds are laid on an insulating layer, the term floating screed is used, which is a screed laid on an acoustic and/or insulating layer and completely separated from other building elements, such as walls and pipework.

Other definitions relate to the material itself. Fine concrete screeds consist of sand/cement material that contains a proportion of aggregate of nominally 10 mm single size, while a sand/cement screed contains a sand of up to a nominal 5 mm in size.

The use of proprietary products may now reduce the risk of cracking, curling, and hollowness.

Sand/cement screeds

The majority of heated screeds are made with cement and sand mix. A semi-dry consistency is necessary to enable the screed

Mechanical engineering issues

Screeding issues

to be finished to a degree of accuracy. A semi-dry consistency of screed demands good compaction and high levels of workmanship to ensure soundness. However, a high surface accuracy may be difficult to achieve, and a further levelling or smoothing compound may be required.

For floating screeds a minimum thickness of 75 mm is required for commercial installations (65 mm for domestic installations), with a minimum thickness of 25 mm over the pipes (*BS 8204-1*).

4 Fine concretes are commonly used in screeds thicker than 50 mm. They can ease compaction effort and potentially reduce shrinkage. For floating screeds a minimum thickness of 75 mm (for commercial applications) is required (table 1). The proportion of aggregate incorporated in the screed is necessarily low.

Although the thermal insulating properties of no-fines screeds are three to four times better than a cement/sand screed, it is not sufficient to use a no-fines screed as an insulation layer without the use of additional insulation. Its thermal efficiency is not sufficient to replace polystyrene insulation in a heated floor.

Calcium sulfate and anhydrite screeds

Calcium sulfate (anhydrite and semi-hydrite) screeds are traditional hand-laid screeds.

Synthetic anhydrite is a by-product of the chemical industry. When processed it forms a binder similar to gypsum that can be used with aggregates and admixtures to form a dense screed material. Its advantages are:

- ☐ A low drying shrinkage
- ☐ the free water content is chemically combined and therefore the drying time is less

Key screeding watchpoints

- ☐ Agree the consistent use of terminology (such as levelling or wearing screed) with the m&e design engineer and underfloor heating contractor
- ☐ Define the location of joints. This information should be transferred onto the drawings used by the underfloor heating supplier/sub-contractor
- ☐ Provide details of the proposed screed material to the heating designers
- ☐ Specify whether a levelling or smoothing compound may be required

Material	Minimum thickness mm	Cover over pipework mm	Standard
Traditional cementitious sand/cement	75 (65)	25	*BS 8204-1*
Traditional calcium sulfate	40	35	*CIRIA Report 184*
Pumpable self-smoothing calcium sulfate	40 (35)	25	*BS 8204-7*
Pumpable self-smoothing cementitous	40 (35)	15	*BS 8204-7*

Table 1: The properties of different screed materials used with underfloor heating systems. Domestic measurements are in brackets. ©The Concrete Society.

Also see

1 Glossary, page 22; Table 1 above
2 Mechanical information, page 6
3 Glossary page 22
4 Figure 5, page 13

Standards on page 21

Further reading on page 21

Glossary on page 22

Detailed design: screeding 2

than sand/cement screeds

☐ good density and low coefficient of thermal movement.

A major disadvantage of synthetic anhydrite is its intolerance to moisture. However, the ability to lay large areas with little risk of cracking or curling, and with relatively low thermal expansion, makes synthetic anhydrite a suitable material for heated screeds.

For floating screeds the minimum thickness is 40 mm. Ferrous reinforcement should not be used due to the risk of corrosion.

Pumpable self-smoothing screeds

Pumpable screeds are covered in *BS 8204-7: 2003*. As these are proprietary systems, it is essential that the advice of the manufacturer or supplier is sought. Pumpable screeds are based on special cementitious or anhydrite/semi-hydrite binders with selected aggregates, additives, polymers and admixtures which, when mixed with water, produce a workable flowing material which has self-levelling or self-smoothing properties. The consistency allows the materials to be pumped.

1 Cement-based pumpable screeds tend to have a restriction on thickness due to the heat of hydration emitted and are generally not used for floating screeds. The minimum thickness of a calcium sulfate-based screed material is 40 mm for commercial use, and 35 mm for domestic applications (see table 1).

Heating pipes should be secured firmly to prevent flotation in the wet screed. The flowing material must also be prevented from getting between the insulation boards. The minimum thickness above the pipes should be 35 mm for calcium sulfate screeds, 25 mm for pumpable calcium sulfate screeds, and 15 mm for cement-based pumpable screed (table 1).

Drying the screed

2 Heating should only be applied according the instructions supplied by the underfloor heating system. For a cement-based screed this should be after it has cured and dried; for calcium sulfate, heating should only be applied seven days after laying.

3 In all cases the screed should be heated very slowly to their operating temperature and maintained for several days before cooling to room temperature, but not below 15°C, before installing flooring.

Note that the usual operating surface temperature is 27-29°C but can be as high as 35°C. Higher temperatures can adversely affect the floor covering and the stability of calcium sulfate screeds.

Floor construction

While the design of a floor should be a top-down process, rather than bottom up (figure 5), it is vital that the concrete base is not uneven. If it is uneven, the insulation may collapse causing cracking of the screed (figure 6).

All materials based on cement shrink as they dry – a characteristic that is aggravated by underfloor heating systems. Materials also tend to expand and contract with changes in temperature, and this is also aggravated by underfloor heating systems. This drying, shrinkage and thermal movement causes the screed to crack. The specifier must think of this at the design stage.

Due to this shrinkage and movement, wearing screeds are generally specified with movement joints at set positions. The specifier should detail these joints at the start of the contract.

The type of flooring will affect the

Mechanical engineering issues

Screeding issues

positioning of joints in the screed and therefore the positioning of the pipework. Guidance for the installation, positioning and spacing of joints in screeds is specified in *BS 8204-2*.

Finishes

Levelling screeds, which are specified to *BS 8204-1* are either jointed or unjointed depending upon the flooring to be laid on them. Thin flexible floorings such as vinyl sheet, tiles or carpet are usually laid on screeds
3 without joints.

With some floorings such as natural stone and clay tiles, the flooring itself requires movement joints. These movement joints, detailed in *BS 5385*, must be to a depth one third the screed thickness and must also pass through the levelling screed. In such cases the position of the movement joints in the flooring and levelling screed will affect the layout of the underfloor heating system.

Where the flooring itself does not normally require joints, such as vinyl sheet, problems

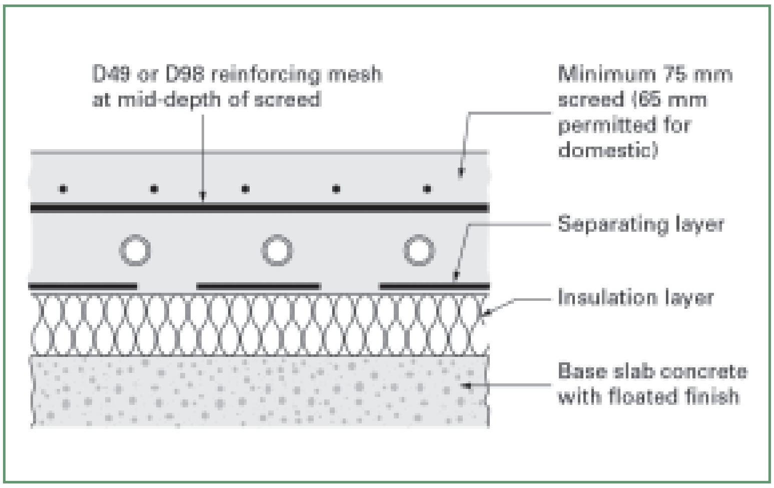


Figure 5: Cement/sand or fine concrete construction. ©The Concrete Society.

Key screeding watchpoints

- ☐ Be familiar with the properties of the screed and understand their limitations
- ☐ For pumpable screeds, be aware of the minimum screed cover to pipework – 40 mm for commercial, and 35 mm for domestic premises
- ☐ Scheduling should take account of the timing for pipework commissioning, screed curing, screed drying and flooring requirements

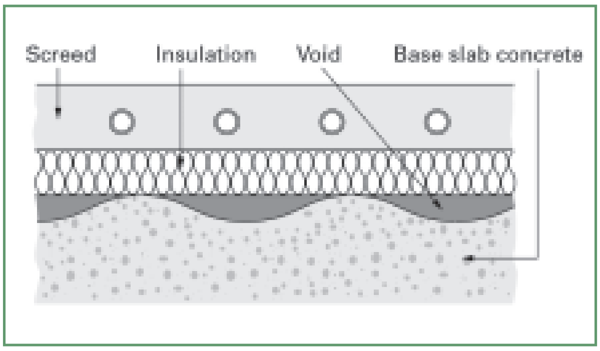


Figure 6: If the concrete base is uneven, the insulation may bridge undulations. When the screed load is applied the insulation may collapse causing cracking of the screed. The revision to *BS 8204* will require the level to be better than 3 mm under a 2 m straight edge. Tamped bases may need levelling or a regulating layer prior to the insulation being placed. ©The Concrete Society.

Also see

1 Services installation, page 16
2 Services commissioning, page 18
3 Services design, page 8

Standards on page 21

Further reading on page 21

Glossary on page 22

Detailed design: screeding 3

arise due to the cracks which occur within the screed being live cracks (in other words opening and closing) due to the imposed thermal movement.

The movement in the cracks created by thermal expansion and contraction can cause distress and usually stretching and rippling of the flooring over the cracks (figure 7).

To prevent such disturbance to the flooring system, movement joints must be detailed in the levelling screed. Again, these joints, the flooring joints and the layout of the panels of underfloor heating must coincide.

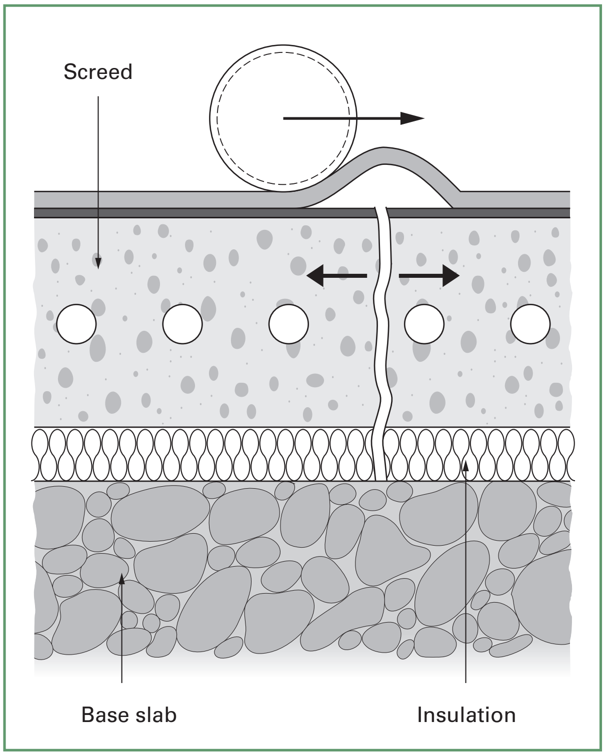


Figure 7: Cracks caused by drying shrinkage may be live due to imposed thermal movement, and may cause ripples in thin flooring. This could be exacerbated by heat concentrating locally through the crack, softening the sheet flooring. ©The Concrete Society.

Screeds: services design issues

The choice of flooring depends on the underfloor heating application.

1 A thick flooring (high thermal inertia) is recommended in buildings where there are no abrupt changes in latent loads. A thin flooring (low inertia) allows a faster response time, which is useful in houses, for example, where there can be abrupt changes in loads from people entering and leaving the rooms, or from changes in solar loads.

2 The generally recommended sand/cement screed cover over pipework is 25 mm. This assumes an overall screed depth of 65 mm for domestic use and 75 mm for commercial use. This will vary depending on the size of pipework, but should meet the relevant *British Standards* for screed thickness (see Table 1).

The following measures are needed to control expansion:

- ☐ A peripheral joint of expanded polystyrene all around the slab
- 3 ☐ reinforcement can help to reduce the width of cracks and prevents lipping. It should be placed across pipework within the 25 mm cover thickness and extend at least 150 mm either side (figures 5 and 7).
- ☐ movement joints – definitive guidance on location of joints (whether expansion, contraction or induced) is difficult as it depends on the structural layout of the building, the flooring joint pattern, and the heating circuit layout. *BS 1264-4* recommends joints in stone and ceramic finished screeds every 40 m², of a maximum length of 8 m and an aspect ratio of 2:1.

To avoid fractures, a specific joint must be placed every 8 m across the floor, but this joint need only be cut into the screed to a depth one third its thickness. It should therefore not affect the pipe circuit. Regarding the circuit

Mechanical engineering issues

Screeding issues

pipes, only the supply and return pipes should pass through movement joints.

The position of all joints must be defined at the project stage and shown in the drawings. The planner can therefore design the pipe circuits in a way that only involves supply pipes crossing movement joints.

BS EN 1264 Floor heating – systems and components, Part 4: Installation states:

In the case of heating screeds of type A and C, movement joints and perimeter joints shall only be crossed by connecting pipes and only in one level. In this case, the connecting pipes shall be covered with a flexible tube of some 0·3 m in length.

In other words, the pipe is debonded for 300 mm on either side of the joint.

Pre-installation issues

It is easier and cheaper to resolve as many issues as possible at the design stage rather than on site. For example, the entire floor area must be free of operatives from all other trades while the pipework is installed. The building should also be wind and water-tight before installation of the underfloor heating begins. The contract administrator or architect will have to develop a programme that allows other trades to work in other areas during pipework installation, but this may require the programme to be extended.

It needs to be impressed upon the client that there will come a point in the design process – earlier than they are used to on more conventional projects – when no more changes to the general structure and floor plan layout can be accommodated with the underfloor system design. Once the floor screed is laid, it is difficult and expensive to make major changes and still expect the underfloor heating system to work effectively.

Key m&e watchpoints

- ☐ Ensure that the chosen floor covering is suitable for the desired response time of the underfloor heating system
- ☐ Check that the edge insulation is of the correct specification to act as an expansion element
- ☐ Provide design details (movement-absorbing materials and joints) that control expansion
- ☐ Ensure the client is aware that any major building alterations late in the project may compromise the effectiveness of the underfloor heating system

Key screeding watchpoints

- ☐ The position of all joints must be defined at the project stage and shown on the drawings. This planning should involve the mechanical planner and screeding contractor as well as the architect to ensure continuity. Note that it is not possible to provide definitive guidelines for joint frequency

Also see

1 Pumpable screeds, page 12
2 Table 1, page 11
3 Figure 5, page 13

Standards on page 21

Further reading on page 21

Glossary on page 22

Issues to address during

Installation

The quality of the installation will ultimately determine the performance of the system.
It is very important for all the contractors involved in an underfloor heating installation to understand the principles of the technology, so it can be integrated properly and efficiently into the construction process. The m&e and screeding contractors will need to give extra thought to the sequencing of other works on-site to avoid delays and lost production while the pipework is being laid.

Services installation issues

Careful thought is needed as to who will be responsible for issuing instructions to the underfloor heating specialist. It is in everyone's interest to make sure that this is clearly understood before any work starts on site, as instructions from the wrong source can be expensive and lead to delays.

Once the order has been placed, the underfloor heating specialist should provide a detailed programme covering the entire underfloor heating installation works, including adequate notice periods for testing, witnessing, inspection and commissioning.

The main contractor will need to give extra thought to the sequencing of other works on-site to avoid delays and lost production while the pipework is being laid.

Before the works begin, the tenderer/contractor should provide full sets of working drawings for approval by the client, architect, project manager, quantity surveyor or engineer, and no works should begin until approval for such drawings has been obtained.

The entire floor area must be free of operatives from other trades while the pipework is installed. The building should be both wind and watertight before installation of the underfloor heating pipework begins.

The main contractor needs to avoid damage to the pipework once it is installed, by arranging for the screed to be laid as soon as possible after installation of the pipework.

Pipework fixing

The pipework can be fixed by a number of methods, such as the use of a rail onto the insulation, with securing clips at set distances into which the pipework is laid out.

Another method is to lay the pipework out in the desired pattern and simply push a clip over the pipe into the insulation. A third method is to fix the pipe to a steel mesh. This provides flexibility, but can take longer to install. The screed may be specified as needing reinforcement by means of steel mesh. This would not be a pipe-fixing steel mesh (figure 8).

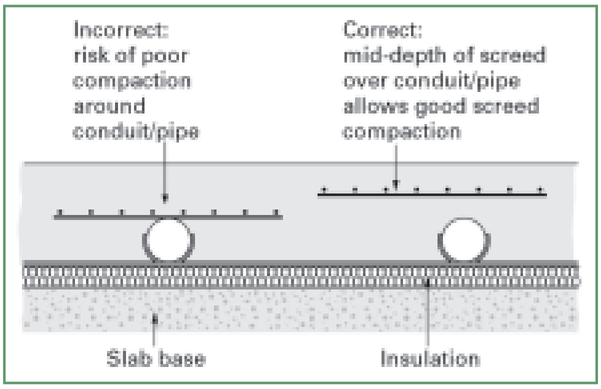


Figure 8: Incorrect and correct ways to apply mesh reinforcement. Note that the mesh is not used to anchor the pipework. ©The Concrete Society.

A layer of screed is then laid on top of the pipework to act as the transfer medium, and to level and strengthen the floor ready for the final flooring of carpets, tiles or stone.

Note that pipework fixings must be carefully selected to ensure that they do not endanger the integrity of the insulation or other materials. The contractor will also need to be told that the heating must not be used to dry out structure as a lengthy running up period is required to bring the system into use. This needs to be allowed for in the programme.

After the underfloor heating pipe has been laid, it should be subjected to a pressure test at twice the working pressure (*BS EN 1264-4*). While *BS EN 1264-4* requires testing at a minimum of 6 bar, underfloor heating suppliers recommend testing up to 6 kg/cm^2, maintained for 24 h. This pressure should also be maintained during laying of the screed.

	Mechanical engineering issues
	Screeding issues

Screeding installation issues

2 Any irregularities in the base must also be levelled as necessary in order to ensure that the insulating panels sit flat. This will prevent the insulation bridging a depression and the floor collapsing under load (page 12, figure 6). If reinforcing mesh is required, it should be installed as shown in figure 8 opposite. However, it is very unlikely that reinforcement will be necessary.

3 A screed is generally finished with a wood float, with the level assessed under a straight edge (3 mm in 2 m as in *BS EN 8204* amended in 2003).

2 The surface finish required of a screed is dependant on the flooring to be applied. Many floor coverings are fixed with adhesive or primer. These must be compatible with the screed especially calcium sulfate or proprietary types of screed.

Pumpable screeds tend to find their own level, but are sometimes agitated with a special tool to assist the smoothing.

The internal partition walls and any drainage system must be completed. The zone under the distribution manifolds must be finished. It is also advisable for the exterior doors and windows to be installed if the work is being done during a season where there is a risk of frost.

Pressure testing and drying

4 After the underfloor heating pipe has been laid, it should be subjected to a pressure test at twice the working pressure. This pressure should be maintained during the laying of the screed.

The screed should be protected from rapid drying by curing for at least ten days. It should also be protected from draughts and direct sunlight.

Key m&e watchpoints

- ☐ Ensure the underfloor heating system supplier provides a detailed programme covering the underfloor heating installation, including testing, witnessing, inspection and commissioning, including screed drying time.
- ☐ Ensure the contractor provides full sets of working drawings for approval
- ☐ Ensure that the building is wind and watertight before installation of the underfloor heating pipework begins
- ☐ Ensure that pipework fixings do not endanger the integrity of the vapour barrier

Key screeding watchpoints

- ☐ Level the base to ensure that the insulating panels sit flat. This will prevent the insulation bridging a depression
- ☐ Ensure the screed is protected from rapid drying by curing for at least seven days.

Also see

1 *BS 1264-4;* timings, page 19
2 Figure 6, page 12
3 Screed finishing, page 19
4 Services commissioning

Standards on page 21

Further reading on page 21

Glossary on page 22

Issues to address during

Commissioning

The commissioning period is a critical to the success of an underfloor heating system. Commissioning not only involves testing the heating system, pipework and the connections, but is also the process by which the screed is dried and cured. Timing, temperature and measurement are very important to the process. It is not simply a case of switching the system on and walking away.

Services commissioning issues

With a screeded floor system it is essential that the screed is allowed time to dry out thoroughly, and that such time is allowed within the construction process. Failure of screeds due to insufficient moisture control can result in very expensive and disruptive remedial works. The amount of time required for screed to dry out thoroughly will depend on the type and thickness of screed to be used.

1 After the underfloor heating pipe has been laid, it should be subjected to a pressure test at twice the working pressure. Underfloor heating suppliers usually recommend testing to a minimum of 6 kg/cm², maintained for 24 h.

2 The screed should be protected from rapid drying (it must be cured) for at least three days. It should also be protected from draughts and direct sunlight. After this period, there are several drying-out options given in the current guidance.

BS 8204-1 recommends that the screed should be allowed to dry out as slowly as practicable after curing to reduce the risk of curling. Accelerated drying must not be used.

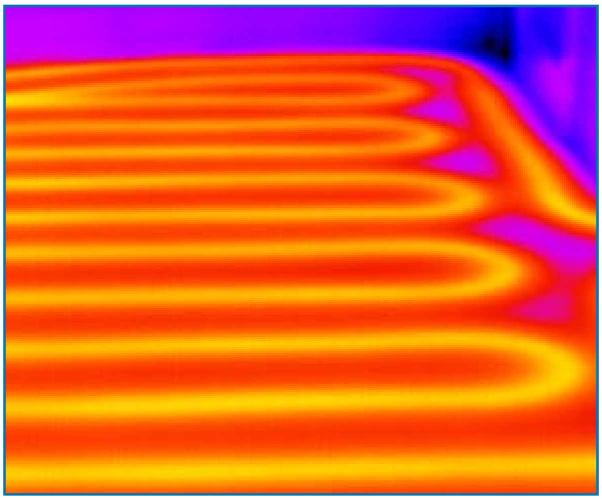
Waiting for the screed to dry out depends on the ambient conditions. For sand/cement screeds to *BS 8204-1*, it is suggested as one day for each millimetre of thickness of the first 50 mm, followed by an increasing time for each millimetre above this thickness.

BS EN 1264-4: 2001 suggests that sand/cement screeds should not be heated for at least 21 days after laying. Although Anhydrite screeds should not be heated for at least seven days after laying, the screed manufacturer may indicate otherwise. The temperature of the water entering the circuits should be not more than 25°C (or 15°C above the temperature of the unheated floor screed) for at least three days, and then raised to the maximum design temperature and maintained for a further four days.

Once the screed has dried and the heating has been tested, the flooring system may be laid. Floorings need to be acclimatised to site conditions prior to laying, and such treatment depends on the material. Manufacturers' instructions should always be followed.

The possibility of damage to the flooring over joints and cracks, such as the rippling of thin sheet, can be caused by the reversal of curling as the moisture redistributes once the flooring is laid. This can be reduced by covering the screed with impermeable sheeting for seven days before laying flooring.

The services contractor should resist any attempts by other contractors to subject the screed to integrity testing, such as crushing resistance as laid down in *BS 8204-1: 2002*. The integrity test could cause damage to underfloor heating pipework if the test is carried out on a very poor screed.



Above: An effective way of checking the quality of the installation is to carry out a thermographic survey. Thermographic surveys are available from BSRIA. ©BSRIA.

Mechanical engineering issues

Screeding issues

Screed finishing issues

A screed needs to be cured for at least three days to prevent it drying out rapidly as the moisture within the screed is required for the hydration of the cement to ensure that the screed reaches its full strength. *BS 8204-1* recommends that the screed should be allowed to dry out as slowly as practicable after curing to reduce the risk of curling. Accelerated drying must not be used.

2 Clause 6.1 in *BS 8204-1* suggests an approximate drying time, as drying is influenced by ambient conditions, screed quality, thickness and surface finish. This period for sand/cement screeds is suggested as one day for each millimetre of thickness for the first 50 mm, followed by an increasing time for each millimetre above this thickness. A screed of about 50 mm could be expected to dry under good conditions in about two months. A 75 mm thick screed would probably take around three months.

It has been suggested that when a screed is first heated it drives off water in the top of the screed, but moisture remains trapped below the pipes. The screed must be allowed to cool to room temperature (not below 15°C) before flooring is laid.

During this period of lower temperature, the moisture migrates to the drier regions. Consequently when the heating is next switched on, this residual moisture is driven off, possibly disrupting the flooring. This is especially true if the flooring is impermeable such as vinyl flooring. This could result in bubbling of the flooring. It is recommended that further cycles of heating and cooling are carried out before laying the flooring.

Before a flooring can be laid, the screed must be at a moisture level compatible with the chosen floor covering and its adhesive.

Key m&e watchpoints

☐ The specialist contractor/ commissioning contractor should provide one complete and accurate set of as fitted drawings. For the screed interface, these should cover:
- the position of all items of plant and equipment that are associated with the installation
- the routes and sizes of all pipework, including that buried within the floor
- the position of all items of equipment including thermostats, manifolds, valves and controls, and detailed diagrams of each manifold clearly identifying each circuit, and which areas are served by each

☐ The temperature of the water entering the circuits should be raised slowly to between 20°C and 25°C for three days, and then raised slowly to the maximum design temperature and maintained for a further four days

Key screeding watchpoints

☐ Calculate the required drying time for sand/cement screeds based on one day for each millimetre of thickness for the first 50 mm, followed by an increasing time for each millimetre above this thickness

☐ Proprietary screeds dry at different rates - see manufacturers' instructions

Also see

1 *BS EN 1264-4 cl. 4.3* (see Standards)
2 *BS 8204-1 cl. 6.1* (see Standards)

Standards on page 21

Further reading on page 21

Glossary on page 22

Cost model

The actual costs associated with an underfloor heating system and screed depends on the context. However, the fixed costs of the heating system and the installation works are relatively straightforward. The following cost model has been prepared by the cost research departments of Mott Green & Wall and Davis Langdon & Everest, specialists in the cost planning and cost management of building services installations.

Costs provided by underfloor heating companies need to be carefully examined to find out exactly what is included. In some cases insulation will be provided by the underfloor heating contractor, whereas in other installations it may be provided by the builder.

The following costs are indicative current costs for underfloor heating and screeds based upon medium sized projects with an underfloor heated area of between 300 m^2 and 2000 m^2.

The rates shown are applicable to competitively tendered commercial contracts in Outer London in July 2003.

The underfloor pipework installation rates include for the mechanical and electrical contactor's preliminaries. Main contractor's preliminaries are also included at 12%.

Excluded costs

The cost rates for the underfloor heating and screed cost model exclude the following elements:

- ☐ Final flooring finish or wearing screed
- ☐ acoustic or rubber sound absorption matting
- ☐ any allowance for above average floor loadings
- ☐ part-load charges for small quantities of pumpable screed
- ☐ main items of mechanical and electrical plant and primary distribution
- ☐ any interface with a computerised building management system
- ☐ builder's work in connection with the underfloor heating system (for example, cutting holes and cupboards for pump control units)
- ☐ contingencies
- ☐ VAT.

The following mechanical and electrical underfloor heating system data are presented per square metre area of screed.

Mechanical and electrical cost data

Underfloor pipework installation:	**£19.50/m^2**
Pump control unit with local controls (manifold):	**£8.50/m^2**
Electrical involvement from local power supply:	**£3.50/m^2**
Sub-total underfloor heating cost	**£31.50/m^2**
Main contractor preliminary cost on m&e underfloor heating (12%):	**£3.80/m^2**

Screeding cost data

The following screeding cost data are presented per square metre area of screed.

Cement sand screed (cement/sand ratio 1:3) 75 mm thick:	**£17.00/m^2**
Reinforcement (D49/98):	**£3.00/m^2**
Underfloor insulation deck (80 mm thick):	**£12.50/m^2**
Separating layer (500 g polythene sheet):	**£0.50/m^2**
Tamped finish to concrete base:	**£0.70/m^2**
Sub-total for cement and sand screed	**£33.70/m^2**

Total system cost (inclusive of above m&e and screeding costs) **£69.00/m^2**

Alternative screed rates

Fine concrete screed (75 mm thick): cost as cement sand screed.

Pumpable screed, anhydrite or hemihydrite (75 mm thick, reinforcement not required): **£32.70/m^2**

Total using pumpable screed **£68/m^2**

Standards

Designers and contractors should always follow the guidance laid down in prevailing standards. The standards governing screeding and underfloor heating are generally compatible, but variations in advice exist, especially where the timing of operations are laid down. Such discrepancies should be identified and resolved in discussion between the screeding specialist and the underfloor heating supplier.

Concrete screeding standards

BS EN 1264-4: 2001 *Floor heating. Systems and components. Installation.*

BS 5385-3: 1989 *Wall and floor tiling. Code of practice for the design and installation of ceramic floor tiles and mosaics.*

BS 5385-4: 1992 *Wall and floor tiling. Code of practice for tiling and mosaics in specific conditions.*

BS 5385-5: 1994 *Wall and floor tiling. Code of practice for the design and installation of terrazzo tile and slab, natural stone and composition block floorings.*

BS 8203:2001 *Code of practice for installation of resilient floor coverings.*

BS 8204-1: 2002 *Screeds, bases and in situ floorings – Part 1: Concrete bases and cement sand levelling screeds to receive floorings – code of practice.*

BS 8204-2: 2002 *Screeds, bases and in situ floorings – Part 2: Concrete wearing surfaces – code of practice.*

BS 8204-3: 1993 *Screeds, bases and in situ floorings – Part 3: Code of practice for polymer modified cementitious wearing surfaces.*

BS 8204-4: 1993 *Screeds, bases and in-situ floorings. Code of practice for terrazzo wearing surfaces.*

BS 8204-6: 2001 *Screeds, bases and in-situ floorings. Synthetic resin floorings. Code of practice.*

BS 8204-7: 2003 *Screeds, bases and in-situ floorings. Pumpable self-smoothing screeds. Code of practice.*

Mechanical engineering standards

BS 7291-1: 2001. *Thermoplastic pipes and associated fittings for hot and cold water for domestic purposes and heating installations in buildings. General requirements.*

BS 7291-2: 2001. *Thermoplastic pipes and associated fittings for hot and cold water for domestic purposes and heating installations in buildings. Specification for polybutylene (PB) pipes and associated fittings.*

BS 7291-3: 2001. *Thermoplastic pipes and associated fittings for hot and cold water for domestic purposes and heating installations in buildings. Specification for cross-linked polyethylene (PE-X) pipes and associated fittings.*

BS EN 1264-1:1998. *Floor heating – Systems and components. Definitions and symbols.*

BS EN 1264-2: 1998. *Floor heating – Systems and components. Determination of the thermal output.*

BS EN 1264-3: 1998. *Floor heating – Systems and components. Dimensioning.*

BS EN 1264-4: 2001. *Floor heating – Systems and components. Installation.*

BS EN 1264-4: 2001. *Floor heating – Systems and components. Installation.*

DIN 4725-4. *Hot water floor heating systems – Design and construction (plus Amendment A1).*

Further reading

Gatfield M J, *Screeds, flooring and finishes – selection, construction and maintenance* Construction Industry Research and Information Association (CIRIA) 1998, ISBN 0 86017 496 4.

Pye P & Harrison H W, *Building Elements: Floors and flooring – performance, diagnosis, maintenance, repair and the avoidance of defects* BRE 1997, ISBN 1860811736.

Chaplin R G, *Floor levelling screeds*, British Cement Association (BCA) 1997, ISBN 0 7210 1506 9.

SANDS J. *Underfloor heating systems, the designers' guide* AG 12/2001 BSRIA 2001. ISBN 086022 5288.

SANDS J. *Underfloor heating systems, an assessment standard for installations* AG 13/2001 BSRIA 2001. ISBN 086022 5836.

Energie Guide: *Floor heating and cooling systems, applications of low temperature heating and height temaperature cooling.* Thermie project DIS/1522/97/FR. BSRIA 2002.

Glossary

Building services terms

Underfloor heating	A system of metail or plastic pipes laid in circuits, in a floor screed or below a timber floor system, through which hot water is passed. Some underfloor heating systems use electric elements.
Cross-linked polyethelene	Cross-linked polyethelene (PE-X) comes in three forms, each using a different method of manufacture for the cross linking. Three types are PEX-a (peroxide cross-linked polyethylene), PEX-b (silane cross-linked polyethylene) and PEX-c (radiation cross-linked polyethylene).
Polybutelene	Polybutelene (PB) is typically a multi-layer co-extrusion, with the oxygen barrier enclosed between the Polybutelene inner and outer layers to minimise the ingress of oxygen into the pipework system.
Insulation	Insulation is generally positioned beneath the circuit pipework to prevent downward heat loss. Insulation around the perimeter of an underfloor heating system also accommodates a certain amount of slab expansion when the underfloor heating is in use.

Screeding terms

Screed	Layer of material laid *in-situ* directly onto a base or intermediate layer for one or more of the following purposes ☐ to obtain a defined level (levelling screed) ☐ to provide a wearing surface (wearing screed) ☐ to carry the final flooring.
Floating screed	Screed laid on an acoustic and/or separating layer and completely separated from other building elements (not a floating floor).
Pumpable, self-smoothing screed	Proprietary screed that is mixed into a fluid consistency, that can be transported by pump and will flow sufficiently (with or without some agitation of the wet material) to give the required accuracy of level and surface regularity.
Curing	The process of preventing the loss of moisture from the young screed while maintaining a satisfactory temperature regime, so that the cement hydration process can be maximised.
Curling	Vertical distortion at the edges of a two-dimensional flooring due to differences in temperature or moisture content throughout its thickness.
Drying	The process of losing excess moisture from a screed, after a sufficient curing period, through evaporation.

What are Interface Engineering Publications?

Interface Engineering Publications (IEP) are a series of guides that aim to bridge the gaps in technical knowledge at the interfaces between construction packages. The publications involve reformating existing professional knowledge, developed independently by Co-Construct members, into a single source of guidance.

The objective of IEPs are to reduce failures on site, to create greater understanding of shared processes by clients, designers and contractors, and to improve the construction quality and in-use performance of underfloor heating systems.

Screeds and Underfloor Heating has been jointly researched, edited and produced by BSRIA and The Concrete Society in order to provide comprehensive guidance in a single publication. All the information has been drawn from current research and existing publications, and cross-referenced with the latest regulatory requirements.

For more information on Co-Construct visit www.construction.co.uk.

CO-CONSTRUCT

Co-Construct
c/o BSRIA, Old Bracknell Lane West, Bracknell, Berkshire, RG12 7AH, UK
Tel: +44 (0)1344 426511
www.construction.co.uk