Tiling to Heated Floors

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The Tile Association

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1 FOREWORD

A Technical Working Group of the Tile Association has prepared the paper “Tiling to Heated Systems”.

The paper has been written with the aim of providing advice for all parties in the process of designing or installing tiling to heated floor systems and should be read in conjunction with current and forthcoming British, European and International Standards.

The Tile Association acknowledges the support given by members of the Working Group and The Underfloor Heating Manufacturers Association in the drafting of this document.

2 SCOPE OF DOCUMENT

This document sets out what is considered to be best practice guidance for the use of ceramic tiles (as defined in BS EN 14411), natural stone and resin agglomerated tiles over water-based and electrical heating systems.

Since the first edition of this document the installation of tiled floors with underfloor and under tile heating has become more widespread. This edition updates the advice and information provided by the first edition on what is considered to be best practice for the use of tiles with under floor and under tile heating.

British Standard BS5385-4: Code of practice for fixing tiles in specific conditions offers basic advice on tiling to heated systems; this guidance document provides additional guidance.

3 TYPES OF HEATING SYSTEM

In the case of a structural concrete floor incorporating underfloor heating and topped with a screed, a separating membrane should be installed between the concrete slab and the screed.

3.1.1 Fully floating concrete floor screed, (EN1264 Type A1 system) 65-75mm thick, containing metal wire mesh reinforcement, (see BS8204-1, clauses 5.7, 6.4.4, and 6.9) resting on a layer of suitable thermal insulation, with heating pipes or cables laid above the insulation/screed interface, all supported by the stuctural slab.

3.1.2 Fully floating floor screed reinforced with metal mesh reinforcement, see (BS 8204-1 clauses 5.7, 6.4.4, and 6.9), resting on a layer of thermal insulation, and containing heating pipes or cables, either resting on, or just above the interface between the screed & insulation

3.1.3 Fully floating floor screed, (BS EN1264 Type B system) at least 35mm calcium sulfate or modified cement, where pipes or cables are recessed into grooves within the insulation layer and fitted with metal strip heat conductor panels for upward heat transfer to the screed.

3.1.4 Fully floating floor screed, (BS EN1264 Type C system) to specified average thickness, laid level or laid to falls, with metal wire mesh

reinforcement (a welded steel fabric of 2.5mm diameter wire spaced at approximately 50mm x 50mm centres) laid upon a slip membrane, upon a second layer, not less than 45mm thick, of screed containing heating pipes or cables, all of which rest upon a suitable thermal insulation layer according to Building Regulations by typically 90mm – 100mm thick, supported by the structural slab.

The Underfloor Heating and Installation Guide published by various bodies states (see Bibliography) "There are several types of insulation in general use with UFH systems all with different characteristic to meet a specific range of situations. Generally in addition to the product thermal characteristics, the compressive stress caused by imposed loads and water permeability creates a need to assess other product qualities more thoroughly.

Residential floors usually require 2kN/m^2 Uniformly Distributed Load (UDL), whilst Commercial flooring typically demands a 5kN/m^2 UDL requirement for thermal insulation. Whilst impact load is a factor it is normally attenuated towards zero by the screed covering."

3.1.5 Floating heated screed in dry internal locations, usually calcium sulfate based, containing heating pipes or cables. These heated screeds are thinner and have less thermal inertia and a quicker response than conventional heated screeds of thicker construction. (BS8204-7 refers)

Note:
All warm water heating pipes listed above may be used in summer cooling mode with chilled water at not less than 15 Celsius for effective radiant comfort.

Strand fibre reinforcements are not a suitable substitute for metal mesh reinforcement when used in screed which will take underfloor heating.

3.2 Installed during tiling process (Undertile)

These consist of heating systems that are installed immediately beneath a tiled floor, usually using electrically heated wires. These are available in a number of forms. (See Appendix B).

4 DESIGN CONSIDERATIONS

4.1 Introduction

Current Building Regulations and Compliance documents use parts of BS 1264 to determine floor heating system requirements and for ground heat loss, together with BS 12831 for heat load requirements. This defines the construction and thermal insulations requirements which are referred to in the text which follows.

This requirement applies for all types of screeds including cementitious and calcium sulfate based screeds.

4.1.1 Movement joints

Movement joints are traditionally installed over construction/structural movement joints as in such locations movement is to be expected over the life of the building. Joints in floor screeds and tiled finishes should therefore include expansion joints immediately over such unrestrained construction joints to eliminate risks of cracking.

Since ceramics and natural stone are rigid finishes that will not deform laterally when they are bonded directly to the heated screed with adhesives, the requirements for intermediate movement joints are more essential. This requirement applies for all types of rigid screeds including cementitious and calcium sulfate based screeds.

At the design stage provision should be made for the thermal expansion of the screed and the applied flooring. Taking into account the movement joint positions indicated in sections *4.1* and *9.4* of this document, additional considerations should be observed.

Tiling should only commence when the heating is off and an appropriate screed and room temperature is reached, i.e. above 15°C but not above 20°C. Higher temperatures will reduce the open time of the adhesive and may induce higher contraction stresses on cooling.

4.1.2 Perimeter strip

An isolating perimeter strip must be fitted prior to the screed installation. The compressible expansion strip should be placed around the perimeter of the floor and where tiling abuts columns, curbs, steps and plant fixed to the base.

The isolating perimeter strip should extend from the supporting base up to the surface of the finished floor and permit a screed movement of at least 6 mm. After the screed has been laid the peripheral insulating strip is cut off after completion of the finished floor or cut off at the surface of the screed and a surface movement joint installed within the floor covering e.g. a pre-formed profile or suitable sealant.

4.1.3 Intermediate joints

The width and spacing of intermediate movement joints should be sufficient to accommodate anticipated movement within the floor assembly so that the stresses between the flooring and heated screed remain within acceptable limits. The maximum area bounded by intermediate joints within the heated screed should not exceed panels of 40 sq. metres in area for ceramic and natural stone tiles and 25 sq. metres in area for resin agglomerated tiles. The panels formed should be square to rectangular with a length to width ratio of no more than 8 x 5 metres.

The provision and detailing of intermediate joints should be considered at the design stage and the thermal movements of the substrate assembly should be taken into account plus any other factors, e.g. exposure to strong sunlight. Where heating elements pass through the movement joints in the heated screed the heating elements are required to be sleeved so that the movement at the joint can be accommodated over a greater length of heating element.

To accommodate the differential movement that will occur either between zones of heated screed or concrete operated by separate control systems, or between zones of heated and unheated screed or concrete, these should be isolated by intermediate movement joints through the screed and tile bed.

4.1.4 Pumped screeds

When pumped liquid type screeds are used, it is possible to lay large areas without joints. However, it is a requirement that joints should be inserted into the screed for specific finishes. Where joints are required in heated screed assemblies they will have to be formed during the screeding process. This will require the use of formwork of the use of proprietary pre-formed movement joint profiles, specifically designed for this purpose.

In heated calcium sulfate floor screeds, movement joints should be detailed:

- Over structural joints in the underlying construction. These movement joints through the screed and tile bed should coincide with and be designed to accommodate the same movement of the underlying structural joints.
- At perimeters of floors where the screed abuts walls and upstands.
- As a movement joint through both the screed and tile bed dividing the tiling into areas not greater than 40sqm for ceramic tiles and 25 sqm for resin agglomerated tiles. The areas defined by movement joints should be square to rectangular with the width to length ratio not exceeding 5 to 8.
- As movement joints at significant changes of width of the screed surface and in doorways.
- As a bay joint isolating areas of screed with separately controlled heating circuits.
- At doorway thresholds between separate areas of use.
- At junctions between heated and unheated sections of the screed.

4.2 Undertile Systems

The following are design considerations to be made for the installation of an undertile heating system.

Generally the preparation required prior to installing the undertile heating is the same as the preparation required prior to laying tile adhesive and tiles without undertile heating.

4.2.1 The base should be sufficiently strong and rigid to support the finish.

4.2.2 The base should be sufficiently flat to permit the specified flatness of finished tiling and suitable for tiling in the service conditions to which it will be exposed.

4.2.3 Where direct fixing is anticipated any new cementitious concrete or screeds should be allowed to cure, typically six weeks for structural concrete and three weeks for screed.

4.2.4 Calcium sulfate screed drying time is approximately 1mm/day up to 40 mm thickness in adequate temperatures and drying conditions. This will increase for screeds thicker than 40 mm and in poor drying conditions.

4.2.5 Refer to the Tile Association publication “Tiling to Timber Sheets and Board, Timber Substrates and Alternative Products” for tiling over timber bases.

4.2.6 The substrate should also be clean and dust free, primed if deemed necessary in accordance with the tile adhesive manufacturer's recommendation.

4.2.7 The heating mesh cable should be encapsulated using a thin layer of self-levelling compound or tile adhesive.

4.2.8 Ensure the floor sensor is in place before tiles are fixed.

4.2.9 Ensure the system does not exceed manufacturer's recommended temperatures onto timber floors.

4.2.10 All areas should be adequately earthed in accordance with BS7671 (17th edition).

4.2.11 Consideration should be given to using an insulated tile backerboard on top of the substrate for additional insulation and be installed in accordance with the manufacturers' instructions.

4.2.12 Ensure the system is installed in accordance with national building and electrical regulations and connected by a qualified electrician. This should include the use of a local isolator such as a fused spur and an RCD (residual current device)

5 INSTALLATION OF HEATING SYSTEM

5.1 Electrical systems

The sub-floor should be prepared as normally required for tiling when planning to install underfloor heating.

Prior:

- See Design Considerations section 4.2 and BS7671 Section 753 for preparation prior to the installation of the floor heating.

Installation:

- The system should be restricted to heating the floor that is not covered by fixtures and fittings unless they have air gaps of at least 4cm beneath them which will allow free airflow from all sides. Additionally care should be taken not to heat any areas that will be beneath rugs with a Tog value of 1.0 or higher.
- Install a floor thermostat with floor sensor to achieve thermal efficiency monitor, control and limit the floor temperature to a safe level.
- It is important to ensure that the heating system is tested at every stage of the installation, this means prior to laying the units, once the units are laid and after laying the levelling compound or adhesive. A multimeter capable of reading low and high resistance values should be used to test the system.
- Alarms are available which warn of any damage to the cable.
- Tests should be carried out on the electrical cable:

Continuity 1: between Live – Neutral = signal desired
Lack of a signal indicates there may be a break, though does not confirm it. Some multimeters' signals are not strong enough to get all the way through the resistor wire circuit and may not give a reading.

Continuity 2: between Live/Neutral and Earth = no signal desired
A signal indicates a fault in the insulation between the Live/Neutral and Earth

Resistance: Check resistance of Live to Neutral matches the manufacturer's specifications.

Insulation resistance: This checks that the earth sheathing around the heating cable has not been damaged. Note not all installers will have equipment to undertake this test.

- Each system has different methods of installation, an overview of the popular systems is provided below:

  Conventional loose cable – the heating cable is rolled out across the floor and secured at the spacing recommended by the manufacturer. Initially the heating cable is secured at regular intervals.

  Pre-spaced heating cable on a mat – The mat is rolled out across the floor in strips, upon reaching the end of the room with the first strip, the mesh mat is cut, rotated and the next strip is laid beside the first. Some matting systems are self-adhesive, others are not and require the mats to be securely fixed following manufacturers recommendations. The heating mesh cable should be encapsulated using a thin layer of self-levelling compound or tile adhesive.

- Once the heating system is secured to the floor it will be necessary to make a sketch or take a photograph of the heating installation and record safe clearance dimensions as required by BS7671 Fig753 Part A.

  There are two methods of preparing the substrate to receive tiles. In both these situations given below, the tiles should be fixed in a solid bed (ensuring no voids are left beneath the tiles) using minimum C1S1 adhesive.

  Completely cover the heating system with a suitable self-levelling compound or a minimum C1S1 cement based type tile adhesive, allow this to dry and harden. Then using solid bed fixing, cover with a minimum C1S1 tile adhesive followed by the tiles.

  The advantage of this method is that the electric cables are completely protected.

  Or

  A pourable adhesive may be used to both level over the screed to encapsulate the heating system and solidly bed the tile in a single operation.

5.2 Underfloor systems

Warm water underfloor heating systems should be installed in the manner prescribed by BS EN1264-4, supported by either the BSRIA or CIBSE Design & Installation Guide for Underfloor Heating, and a Specialist System Suppliers Manual.

Electric Cable (Night Storage or On-Peak) conventional underfloor heating systems are installed in accordance with BS60335-2-96, together with the relevant parts of BS7671 Fig 753 and the cable system suppliers' manuals.

On completion of the floor heating system, all necessary tests must be carried out including a hydraulic pressure test for wet systems, and cable resistance and continuity plus earth tests for electrical systems. In both cases a test report should be created and handed over for inclusion in the building log book.

Shortly after completion (within 24 hours to avoid risk of damage) the floor screed should be applied in accordance with British and European Standards. Where a wet system is used, the water pressure should be maintained at operating pressure during the screeding process.

Following the curing and hardening period (21 days for cement screeds) the floor screed should be thermally conditioned to relieve stress and reveal defects (see BS EN 1264-4) for a period of approximately 1 week.

Calcium sulfate screed unheated drying time is approximately 1mm/day up to 40 mm thickness in adequate temperatures and drying conditions. This will increase for screeds thicker than 40 mm and in poor drying conditions.

In common with other screeds, it is very important that good drying conditions are provided for as soon as the calcium sulfate screed is laid. The calcium sulfate screed should be protected from very rapid drying or draughts on the first day, but thereafter atmospheric humidity must be low, i.e. not greater than 65%RH, and the air temperature must be adequate (e.g. 20^{o}C) so that moisture can evaporate. Good ventilation or the use of dehumidifiers can assist in reducing the atmospheric humidity.

Table 1 Sample unheated drying times for calcium sulfate based screeds:

Screed thickness	Drying time in ideal drying conditions
40mm	40 days
50mm	60 days
60mm	80 days

Drying times will increase in adverse conditions when temperatures are lower and/or relative humidity is higher.
The drying rate of a calcium sulfate based screed can be improved by increasing the room temperature and or lowering the relative humidity in accordance with the manufacturer's advice.

Drying can also be improved by using heaters and dehumidifiers and any underfloor heating must be commissioned in accordance with the manufacturer's advice and

slowly brought up to temperature. Heaters and dehumidifiers should not be directed at the screed.

Underfloor heating should be commissioned in accordance with the instructions of the manufacturer, and may be used to speed drying of the calcium sulfate screed 7 days after laying of the calcium sulfate screed.

If it is desired to force dry or accelerate the calcium sulfate *screed drying, and the floor contains heating pipes the following should be adopted:*

Step 1
Allow seven days for screed curing and natural drying

Step 2
Then raise the heating system temperature by 5°C per day for 4 or 5 days until the design maximum is reached.

Step 3
Maintain design maximum floor output at constant room temperature for a further 3 days.

Step 4
Permit the calcium sulfate screed temperature to fall by 10°C per day until the screed surface reaches not less than 15°C room temperature.

6 SELECTION OF HARD FLOORING

The following factors should be considered when selecting hard floorings for use in conjunction with underfloor heating systems.

- The end use of the installed floor after the underfloor heating is operational.
- Where the flooring is to be subject to heavy traffic and loads then the strength, thickness and abrasion resistance of the flooring should be considered.
- Since heated sub-floors will have more movement joints than unheated sub-floors the use of adequately robust pre-formed movement joint profiles should be considered.
- Where the heated flooring is to be used in a wet location the slip resistance of the hard flooring in the wet and dry state will be important. Guidance on slip resistance of hard floorings is given in the TTA Guidance document “The Slip Resistance of Hard Flooring”.
- Resin agglomerated tiles have a very high coefficient of thermal expansion which combined with large format tiles may not be suitable for laying over heated flooring systems. Check with the tile manufacturer or supplier.
- When fixing large format tiles (edge length at least 600mm) it is important to consider the correct provision of movement joints in the screed and tile bed.

Advice should be obtained from the supplier/manufacturer of the flooring with regard to the suitability of the hard flooring when installed on heated sub-floors under the anticipated traffic, loading and spillage of materials.

6.1 The coefficient of thermal expansion of the flooring in relation to that of the heated sub-floor

The coefficient of linear thermal expansion of the hard flooring should not be too dissimilar to that of the heated sub-floor otherwise excess stresses will be set up between the flooring and the sub-floor during heating and cooling cycles. This is because the Young's modulus of hard materials, such as ceramic and natural stone, are high so that a small amount of expansion or contraction exerts a high level of stress on any materials that are restraining the hard flooring.

The coefficient of thermal expansion values normally quoted for building materials are mm per mm x 10^{-6} $^{o}C^{-1}$. This is the increase or decrease in length in millionths of a millimetre per millimetre length per degree Celsius temperature change. As an example, if you had a metre long hard flooring unit, i.e. 1000 mm long, at a temperature of 10°C with a coefficient of thermal expansion of 7 x 10^{-6} $^{o}C^{-1}$, at 30°C the length of the tile would have increased by (1000 x 7 x 10^{-6} x 20) mm = 0.14 mm for the 20°C rise in temperature. Note that if the hard flooring unit were 1000 x 1000 mm then the opposite edges would each move by 0.07 mm.

Particular care should be taken to use hard flooring units and heated sub-floors with similar coefficients of thermal expansion.

Table 2
Sample indicative values of hard flooring materials

Type of Hard Flooring	C.T.E x 10^{-6} $^{o}C^{-1}$	Comparison with Concrete (10)
Group B1b floor tiles	5 to 9	Medium
Group B1a floor tiles	6 to 7	Medium
Agglomerate tiles	20 to 38	Very high, greater than most bases
Granite & Basalt	6 to 9	Medium
Marble	3.5 to 7	Low to medium
Limestone & Dolomite	6 to 10	Medium
Sandstone	11 to 12	Medium
Quartzite	11 to 13	Medium
Glass tiles & mosaics	Approximately 8	Medium
Terrazzo	7 to 13	Medium
Slate	3 to 9	Low to medium

Table 3
Sample indicative values for some materials used on building sites.

Building Materials	C.T.E. x 10^{-6} $^{o}C^{-1}$	Comparison with Concrete
Concrete	7 to 13	Medium
Lightweight concrete	7 to 8	Medium
Cement and sand screed	11 to 13	Medium
Calcium sulfate based screeds	10 to 12	Medium
Mild steel	11 to 13	Medium
Aluminium	24	High
Brass	19	Medium to high
Rigid PVC panels	76	Very high
Wood (across grain)	30 to 35	High
Wood (along grain)	4 to 6	Low
Cement board	7	Medium
Plywood	3 to 5	Low
UPVC	60	Very high
Acrylic plastics	70 to 80	Very high
Glass fibre reinforced polyester	25 to 40	High to very high
Proprietary tile backer boards	Vary with composition	Medium (restrained by composite structure)

Note that some materials, e.g. metals and plastics will show some deformation properties so that the potential expansion will be restrained, however movement of rigid plastic panels, glass fibre reinforced polyester backings, etc. will not be easily restrained. Some of the materials referred to above are unlikely to be used for flooring.

It is important to consider the high coefficient of thermal expansion of resin agglomerated tiles. Consult the tile supplier before using resin agglomerated tiles

with underfloor heating systems. Where large format tiles (i.e. with a single side 600mm or greater) are being used consideration should be given to using wider joint widths. Because there will be a higher rate of thermal movement consideration should be given to using smaller bay sizes.

Size of the flooring units

For larger format tiles and panels any thermal expansion/contraction is cumulative across the area of the tile or panel so that, for a ceramic panel e.g. 3m long, the expansion of the panel across a temperature range of 30°C equates to approximately 0.65 mm which, as a percentage of a 5mm wide joint between adjacent panels, equates to an approximately 12.5% compaction/expansion requirement of the joint grouting mortar, as well as a significant lateral deformation capacity of the panel bedding adhesive; depending upon any corresponding temperature change within the background structure onto which the panels are installed.

Usually in normal environments, the temperature of the tiling layer and its background (internal tiling) may not vary from each other to such extremes, but where tiles and panels, particularly dark coloured ones are installed externally or in areas subject to intense direct sunlight e.g. sun rooms, conservatories, atria etc., the tiling layer can heat up and cool very quickly whilst the background may not.

Conversely, any significant drying shrinkage of the background which continues after tiles or panels have been installed directly onto it may result in the build-up of lateral stresses within the tiling system.

For this reason it is imperative to consider the following when using very large tiles, especially those with a coefficient of linear thermal expansion that differs greatly from that of the heated sub-floor.

- Background is dimensionally stable, flat and level
- Solid bed fixing is achieved, including back buttering where required.
- Dot and dab fixing should be completed avoided
- Minimum joint width between tiles of 3mm
- Bay sizes of not greater than 40 sqm for ceramic tiles
- Rules concerning commissioning are followed

Note that when the value for the coefficient of thermal expansion of any hard flooring material is required this information should always be obtained from the technical data provided by the manufacturer or supplier.

7. SELECTION OF ADHESIVE AND GROUT

7.1 Adhesive Selection

The main consideration to be given to the correct adhesive is to ensure that the selected adhesive is capable of withstanding changes due to thermal effects, in particular conduction of heat through the background to the tiled finish and any associated movement due to thermal gradients.

Therefore a suitable polymer modified cement based adhesive should be selected which conforms to BS EN 12004:2007 “Adhesives for tiles – Definitions and specifications”, having a minimum C1S1 classification.

The selection of a suitable adhesive (BS EN 12004:2007) will also be dependent on factors such as:

- The type and size of tile selected.
- The nature of the type of heated substrate e.g. heated screeds or timber boards with undertile heating.
- The service conditions to which the tiling will be exposed.

Suitable proprietary normal or fast setting to minimum C1S1 adhesives should be used. On suspended timber a C2 S1/2 adhesive with deformable characteristics should be used.

When fixing large format floor tiles (minimum edge length of 600mm), the use of a pourable i.e. lower viscosity adhesive will be advantageous in achieving a solid bed. It is essential there are no voids and all tiles should be fully supported by the adhesive. Further advice however should be sought from the manufacturer to confirm their suitability.

When fixing translucent or light coloured natural stone e.g. marble, a white tile adhesive should be used.

7.2 Grout Selection

Polymer modified cement based grouts should be selected. These will conform to BS EN 13888:2009 “Grouts for tiles – Definitions and specification” for cement grout which is class 2 “Improved cementitious grout with additional characteristics” (CG2).

When chemically resistant, non-absorbent joints are required, consideration should be given to a reaction resin (e.g. epoxide) grout, classification RG1 to BS EN 13888:2009.

8 PREPARATORY WORK

8.1 Underfloor Heated Screeds

Traditional underfloor heating systems consist of either pipes carrying the heated water or electrical heating cables. The use of plastic pipes with heated water is the more frequently used system and are generally supplied and installed as proprietary systems. These underfloor heating systems are installed during the application of the screed mortar and are normally laid within floating screeds laid upon insulation so that the energy is not wasted warming up the structure beneath the heated screed. In lightly loaded domestic situations reinforced cement/sand floating screeds are normally laid at a thickness not less than 65mm. Most proprietary systems utilize pipe staples or clip-rails secured to the insulation surface, or plastic faced moulded insulation with pre-formed pipe retainer clips, to secure the heating pipes and allow the application of a thinner screed, sometimes with a polymer admix.

8.1.1 Cement:Sand Screeds

Any screed containing Portland cement to BS EN 197-1:2011 must be allowed to cure for at least 7 days by preventing the surface from drying and then allowed to dry out for a further 2 weeks. After this drying out period, the screed should be heated slowly at a maximum rate of 5°C per day up to the maximum operating water temperature of 45°C. as recommended by the heating manufacturer and maintained at that level for a further 3 days before being allowed to cool to room temperature. Ensure that the heating system has been turned off or in cold weather turned on so that the screed is held at approximately 15°C before tile fixing commences.

Note 1: Where proprietary rapid setting and hardened screeds are used, advice should be sought from the manufacturer on the need for reinforcement, see clause 9.2, the drying times and initial heating rates.

Note 2: When marble, agglomerated, limestone or travertine tiles are to be fixed, an extended drying time will be required in order to achieve not more than 75% relative humidity at 20°C in the screed.

Note 3: The screed should be conditioned before tiling. A 65mm unconditioned screed will require at least 80 days and a 75mm screed 100 days. If necessary, these drying times may be overcome by using an uncoupling membrane.

The screed should have been installed with a wood float finish to SR1 class of surface regularity so that when checked with a 2 metre straight edge any gap under the straight edge between points of contact with the screed should not exceed 3mm. Guidance on the installation and testing of screeds can be found in BS 8204-1 as well as in appendix C of BS 5385-3. Note that floating screed can be tested for soundness using the BRE (ISCR) screed tester but with heated screeds this should be considered with caution. A failure result can cause a cone of mortar to be punched through the screed and into the insulation to an extent that the heating pipes can be damaged necessitating expensive repairs.

8.1.2 Calcium Sulfate Screeds

The normal unheated drying out period is approximately 1 mm per day for screeds up to 40mm thickness in good drying conditions i.e. warm with adequate ventilation (typically at 20°C, 60% relative humidity).

At greater thicknesses the drying times will be increased. For example in ideal drying conditions: 40mm = 40 days, 50mm = 60 days, and 60mm = 80 days.

Underfloor heating should be commissioned in accordance with the manufacturer's recommendations.

Drying times will be speeded up by commissioning the heating system in the screed as described elsewhere in this document.

The maximum operating water temperature of calcium sulfate based screeds is 45°C.

Further very important information can be obtained from the TTA document "Tiling to Calcium Sulfate based Screeds".

8.2 Undertile Heating

When delivered to site the undertile heating system should be electrically tested.

The undertile heating system must be installed in accordance with the manufacturer's recommendations. All electrical work must be carried out by a Part P competent person/electrician or certified electrician and in accordance with Part P Building Regulations. Electrical Safety 2011 and BS EN 60335-296.

The installer should provide a diagram or photograph of the heating mat installation to the client on completion of installation.

The undertile heating system should be adhered to the substrate following the manufacturer's recommendations.

Once laid the heating cables may be covered by a single layer of a self- levelling compound or suitable proprietary tile adhesive e.g. Class C1S1 adhesive (to BS EN 12004) using the flat edge of the tiling trowel.

N.B. Care must be taken to ensure that the cables are not damaged during this stage and the system tested before tiling begins.
The tile adhesive or levelling compound must be allowed to cure and dry before commencement of tiling in accordance with the manufacturer's recommendations.

8.3 Levelling

For refurbishment work or where the surface of the screed does not meet the tolerances for SR1 surface regularity, consideration may be given to the use of a suitable polymer modified levelling compound. Further advice should be sought from the manufacturer to establish the products suitability for use on heated floors.

8.4 Timber Floors

New timber bases should be designed not merely to carry the additional dead load but also to provide a rigid floor. They should be examined to determine whether they can carry the additional dead load of up to 0.8kN/m^2, and the probable dynamic loading, without excessive deflection.

Additional strength can be provided, where necessary, by taking up the existing boards and stiffening with noggings fixed between joists and joist support sleeper walls.

Existing timber bases may be treated as for new timber floors after removing existing boards.

Alternatively, for floors of small area, the required rigidity may be achieved by overlaying existing timber boards with a suitable proprietary tile backerboard.

Proprietary boards should be of a suitable thickness and be applied in accordance with the manufacturer's recommendations.

Products such as plywood, OSB, MDF or chipboard should be overlaid before using undertile heating products. All bitumen products must be removed or overlaid.

Note: Further advice on the suitability of timber floors to receive a tiled finish can be obtained from the TTA Technical document “Tiling To Timber Sheets and Boards, Timber Substrates and Alternative Products” (due to be revised in 2013).

8.4.1 Uncoupling Membranes

Uncoupling membrane systems provide an intermediate substrate between the tile covering and load bearing substrate. They can be used over a variety of substrates, which include timber, concrete, cementitious screeds and gypsum based screeds, etc.
They are designed to neutralise lateral stresses that occur between the substrate and tile covering, they are not designed to accommodate differential vertical movement.

The membrane works by preventing stresses from the substrate being transferred into the tile covering; this prevents cracking and possibly delamination of the covering material.

They are designed to work with tile adhesives where the bedding must not generally exceed 10 mm.
Uncoupling membranes can be used with undertile heating systems, where the heating is usually placed beneath the membrane, however further advice should be sought from the manufacturer as to suitable positioning and preparation methods.

Uncoupling membranes can perform a number of functions within the tile assembly, which may include waterproofing, crack suppression and vapour management, please consult the manufacturer for further advice.

Uncoupling membranes do not negate the requirement for movement joints within the tile assembly, movement joints should still be installed in line with British Standards.

8.4.2 Deformable Adhesives

Providing the timber floor is sufficiently rigid and stable, over comfort heated floors, consideration should be given to the use of deformable adhesives which meet the requirements of BS EN 12002 Adhesives for tiles – “Determination of transverse deformation for cementitious adhesives and grouts” for S1 or S2.

8.5 Tanking Systems

Where waterproof tanking is required e.g. wet rooms etc., consideration must be given to the use of a proprietary tanking membrane, which is capable of receiving a tiled finish. These systems are designed to be applied to the substrate prior to the commencement of tiling.

Use of appropriate pre-priming treatments and application of any reinforcing matting/tapes or scrim must be carried out as per the manufacturer’s recommendations.

Only earthed electrical heating systems should be used in wet areas. Refer to BS7671 Fig 753.

9 TILE FIXING METHOD

Underfloor heating should be thoroughly checked and commissioned prior to the commencement of tiling. Undertile heating should be checked for electrical continuity and insulation.

9.1 Adhesive Fixing

Tiles should be fixed in a solid bed of adhesive so that as far as possible voids are eliminated beneath the tiles as defined in BS 5385- 3.

The adhesive should be applied using a suitable trowel capable of providing the correct adhesive coverage.

The adhesive will be applied to the dry base in areas up to a manageable area depending on the tile size and type of tile adhesive.

Any depressions (ribbed, keyed profiles, etc.) to the backs of tiles should be filled with adhesive e.g. back buttering of the tile.

Tiles must be firmly pressed into position whilst the ribbed adhesive bed is still fresh, wet and workable, with a twisting/sliding action ensuring that as far as possible no voids are left beneath the tiles.

For larger format tiles i.e. greater than 600mm on a single edge, a low viscosity pourable adhesive, would be advantageous, however it may be necessary to back butter the tile before fixing into place.

9.2 Sand and cement fixing

The sand and cement fixing method may be used in order to achieve a more accurate degree of flatness when laying natural stone flooring. It will also help to accommodate any varying thickness in the tiles.

The heating system, be it water or electric, should already be installed in the screed. A separating membrane should be laid flat over the screed. The screed should be dry and the heating system should be commissioned. (See Section 8.1)

The tiles are laid in a semi-dry bed with the mix being 1:4 cement and sand by volume with sufficient water added to give the required consistency. The bed is applied by trowel to a suitable thickness; the tile then receives a bonding slurry coat to its back and is then beaten down to the exact finished floor level with a rubber hammer. Grouting is then carried out in the same way as for all types of tiling.

Bed Thickness

The surface of the screed should be at the correct level to enable a bed of between 40 – 70 mm under the tile when at finished level.

Separating Membrane

A separating membrane (such as 1000 gauge polythene) should be laid out flat over the entire heated screed and not fixed down.

Movement Joints

The screed should already have movement joints formed in it and these should be carried through the bed and tile and be vertically aligned. The finished floor should have movement joints as frequent as at 5-metre centres in both horizontal directions. If the movement joints in the screed are less frequent than this, then more movement joints need to be installed in the bed and tile. Also a movement joint should be formed at the perimeter. Ensure that the width and design of the movement joints are adequate for the anticipated movement. (See Section 9.4)

Reinforcement

Reinforcement should be incorporated in the fixing bed, (such as 50 x 50 mm x 2.5 mm Gauge 10 suitably welded mesh) and should be overlapped at joints by a minimum of 150 mm. This reinforcement mesh must not pass through movement joints. The mesh should be pulled up into the bed whilst laying to ensure that it is within the bed thickness and not lying under it. (British Standard BS4483:2005 and BS EN 102442 refers)

Bonding Slurry Coat

The bonding, or slurry coat, should be applied over the entire surface of the back of the tile just prior to fixing into the bed. This should be either cement slurry, made up from cement powder, water and an appropriate bonding agent such as S.B.R. Or preferably, a polymer enhanced cement based adhesive (type C2) can be used. If a light coloured stone is being used then the cement or adhesive should be white.

Grouting

Grouting should be carried out as normal using a polymer modified grout (type CG2)

When floor tiles are laid into a wet cement:sand mortar bedding onto a separating membrane over a screed which contains underfloor heating pipes or cables, the method set out in BS 5385-4 should be followed.

9.3 Tile Joints

In accordance with the recommendations given in BS 5385-4 the minimum recommended width of joint spaces in ceramic tiling should be 3 mm. Different joint widths may be required, for example to allow for any dimensional irregularities in the tile, to provide a decorative finish or to accommodate modular size.

The recommended depth of joint should be at least 6 mm.

9.4 Movement Joints

Movement joints in the floor tiling onto heated screeds should be incorporated as outlined in British Standard BS 5385-3. Briefly, this document requires that joints be located over existing and/or structural movement joints. In large floor areas tiles should be divided into bays not exceeding 40 square metres in area for ceramic and natural stone tiles and 25 square metres for agglomerated tiles.

On suspended floors the bay size should be reduced and additional joints provided over supporting walls or beams.

Movement joints should extend through to the depth of the tile, tile bed, screed and should be completely filled and sealed following completion of grouting.

These joints should be a minimum of 6 mm in cross-section. Joints greater than 10 mm should be protected with metal or rigid plastic edging in order to protect the vulnerable edge of tiles on each side of the movement joint from the effects of heavy e.g. wheeled traffic.

The choice of a suitable sealant will depend upon several factors including durability in service, extensibility (movement accommodation), resistance to chemical attack etc.

The joint cavity is normally partially filled with a suitable back-up material that will not bond with the sealant selected for use. Generally, these materials are cellular rubber and plastics e.g. polyethylene foam.

BS 5385-4 Underfloor heating recommends "when bedding in cement and sand mortar onto a separating membrane that intermediate movement control joints should also be incorporated at not greater than 3.5 m centres. These should penetrate through the thickness of the tile and bed down to the separating membrane placed on top of the reinforced base screed."
Account should be taken to the shape of the floor i.e. in an "L" Shaped room, a movement joint should be incorporated where the floor changes direction. Consideration should also be given to dividing these floors into regular rectangular shaped areas separated by movement joints.

10 GROUTING

The grout mortar in the joints between hard flooring units will be subjected to stresses as the temperature of the flooring changes, particularly where there is a large difference between the coefficient of thermal expansion of the flooring and the coefficient of thermal expansion of the heated sub-floor. In most cases the grout mortar will be subjected to compression but in some cases it will be subjected to tension. For this reason it is advisable to use a cementitious grout with increased resilience which will increase resistance to cracking.

Such grouts will be either:

- A normal cementitious grout classified as CG1 mixed with a suitable dispersion admix as recommended by the grout manufacturer to provide the required performance.
- An improved cementitious grout classified as CG2 (as defined in BS EN 13888 and tested in accordance with BS EN 12808).

The use of reaction resin (RG) grouts that provide hard joints should be avoided if at all possible, however where spillage of aggressive chemicals, or contact with materials aggressive to cementitious grouts is likely, the use of such grouts may be required.

11 CLEANING AND MAINTENANCE

Tile finishes need little maintenance and can be kept clean by regular sweeping, then washing with warm water to which a neutral or nearly neutral detergent has been added. Final thorough rinsing with clean water is essential.

Household or commercial cleaning agents such as cleaners containing bleach must never be used to clean stone, these cleaning products will burn or discolour stone finishes. Use only impregnators, sealants and cleaning products that are available from specialist companies and applied strictly in accordance with the manufacturers' advice.

The Tile Association has produced a document "The Cleaning of Ceramic Tiles" which gives detailed advice on cleaning and maintenance.

12 COMMISSIONING AFTER TILING

Commissioning the heating system should be carried out in accordance with the system supplier's manual, whether for warm water or electric cable heating. This will be 7 days for rapid setting tile adhesive and 14 days for normal setting tile adhesive.

However, it is essential that owners, occupiers, and users of the heating systems under tiled floors are aware of the associated fundamentals, most of which have been referred to in previous paragraphs.

Tiling contractors should insist that conditioning of the floor screed has been carried out in accordance with Clause 5 of this document, in observance of BS EN1264-4 before tiling begins.

Conditioning of the system is a worthwhile precaution. This involves setting the initial temperature of the system to achieve a screed temperature of not more than 20°C, before increasing the settings to full output.

13 USE OF FLOOR IN SERVICE

During operation of heating system, any close fitting thermally resistive object should NOT be laid upon, or fixed to electrically heated warm floors.

This applies in particular to thick rugs, mats and beanbags, or in some cases fitted furniture with no airspace below, as damage to cable mats or adhesive interfaces can result in severe cases. – Users should check the tog ratings (measurement of thermal resistance) of carpets and seek professional advice from the system supplier or manufacturer.

This table is taken from "Underfloor Heating Design and Installation Guide"

Table 4
Thermal resistances for typical floor finishes

Thermal resistance	TOG	Floor finish
0.00 m^2K/W	0.0	2mm vinyl tile, 5mm ceramic tile, 3mm epoxy coating
0.05 m^2K/W	0.5	25mm marble, cushion linoleum, 5mm underlay
0.10 m^2K/W	1.0	9mm carpet floor tile, 13mm hardwood, 8mm underlay
0.15 m^2K/W	1.5	Medium pile carpet, wood blocks, 22mm timber laminate
0.20 m^2K/W	2.0	Deep pile carpet with 5mm underlay
0.25 m^2K/W	2.5	Deep pile carpet with 8mm underlay

This does not strictly apply in the case of warm water systems, as pipes are not affected but exceeding the design settings can have a detrimental effect on tile adhesives and close fitting furniture.

Maximum operational comfortable floor surface temperatures for tiles are defined in BS.EN 1264 Parts 1-4.

This table is taken from “Underfloor Heating Design and Installation Guide”

Table 5
Maximum values for floor temperatures as described in BS EN 12164

Description	Max floor surface temperature 0C	Design room temperature 0C	Heat Emission W/m^2
Occupied area	29	20	100
Peripheral area	35	20	175
Bathroom or similar	33	24	100

Appendix A
Types of Floor Heating Systems

Figure 1
Type A wet system

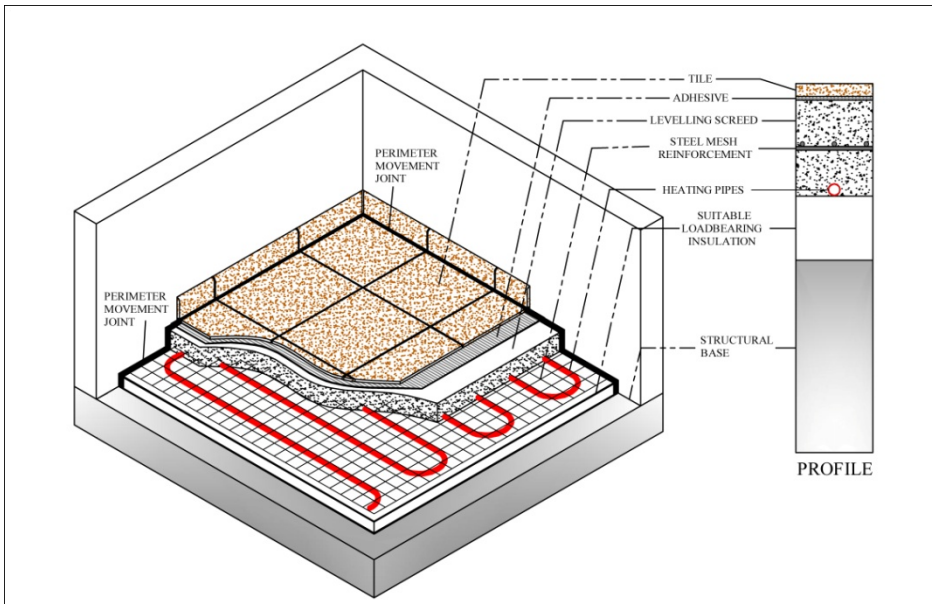


Figure 2
Type B wet system

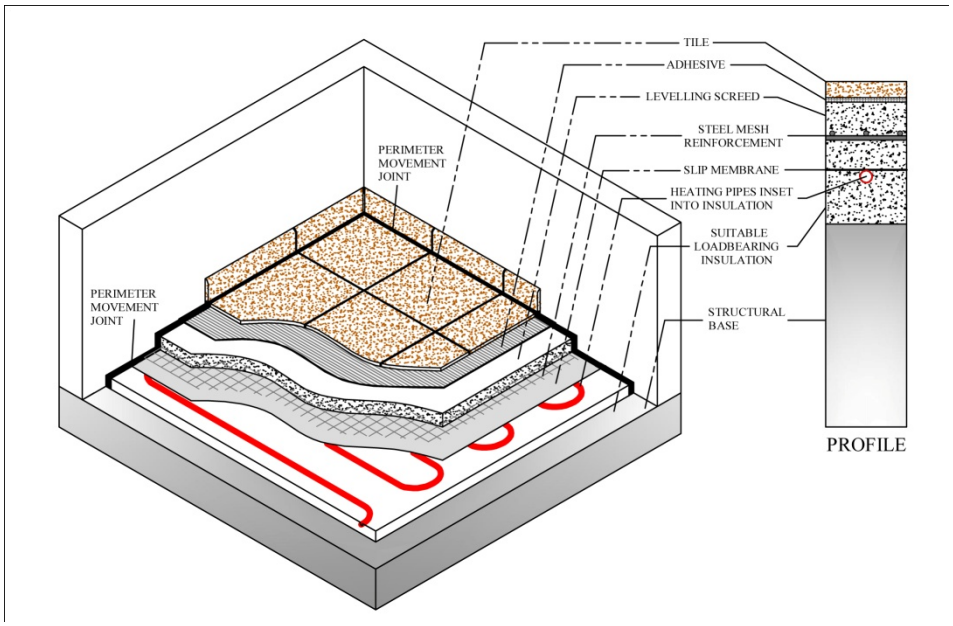


Figure 3
Type C wet system

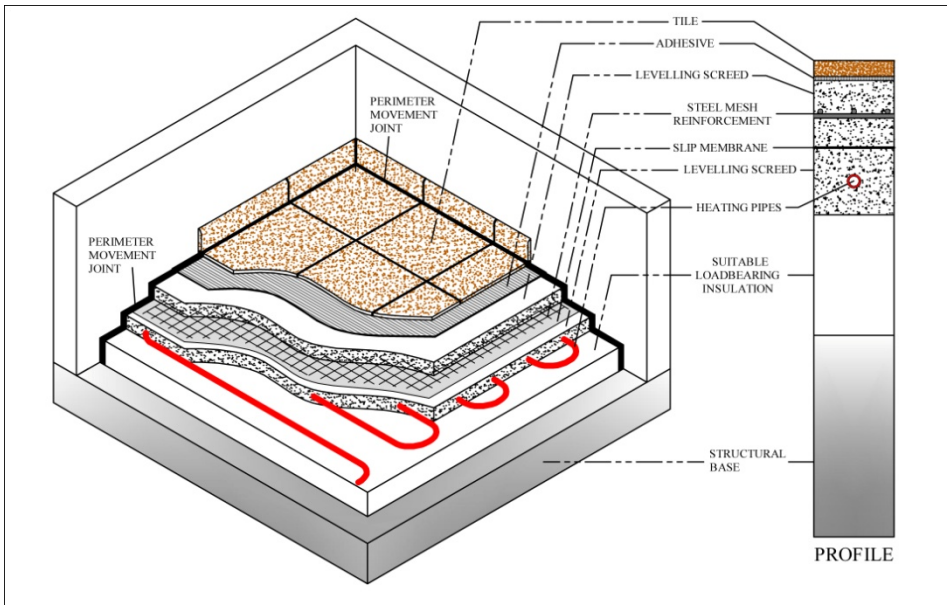


Figure 4
Cable on mat system

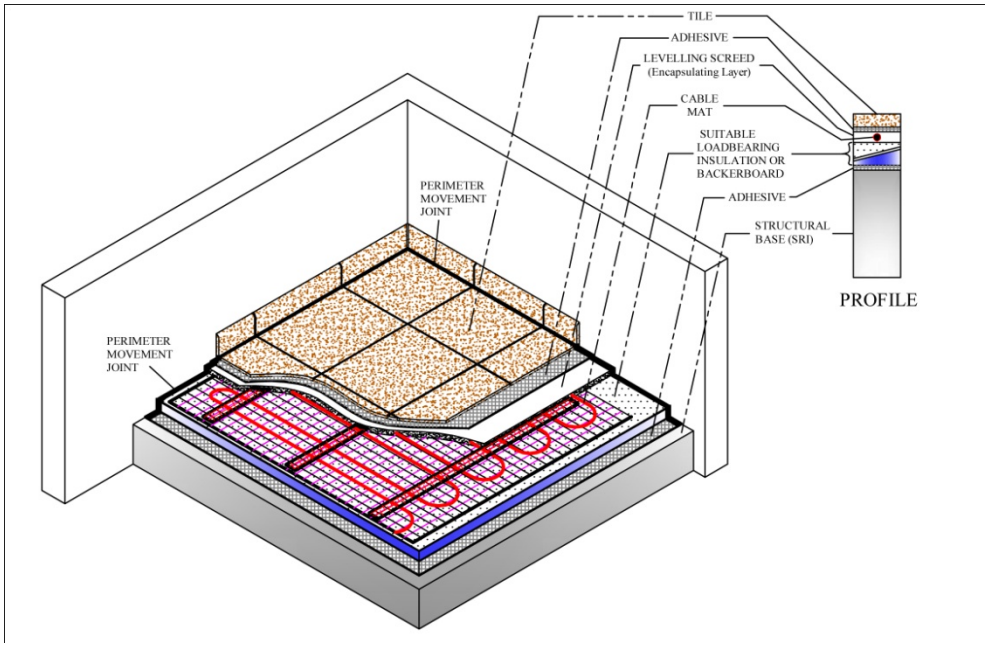
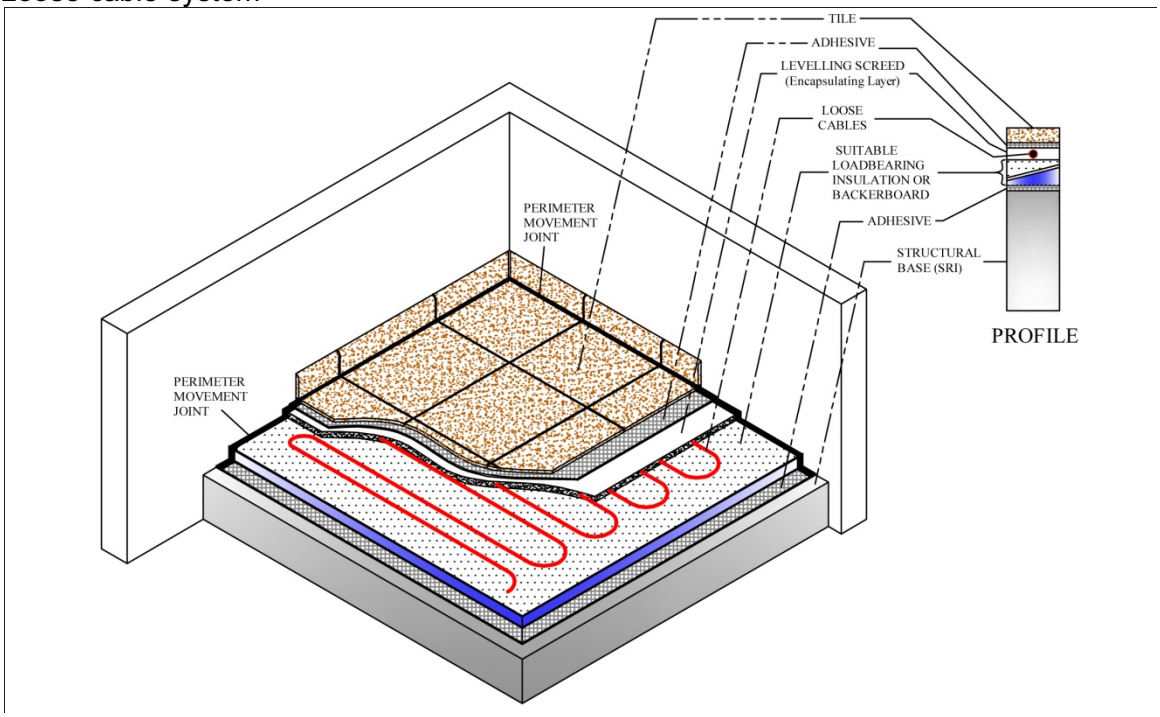


Figure 5
Loose cable system



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BS EN 12004:2001 Adhesives for tiles. Definitions and specifications

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Tiling to calcium sulfate screeds
Tiling with resin agglomerated tiles
Tiling to timber sheets and board, timber substrates and alternative products

Underfloor Heating Manufacturers Association

Underfloor Heating Design and Installation Guide" published by The Association of Plumbing and Heating Contractors, the Chartered Institution of Building Services Engineers, CORGI Direct, the Heating & Hot water Industry Council, the Building & Engineering Services Association, the Institute of Domestic Heating & Environmental Engineers, the Chartered Institute of Plumbing and Heating Engineering, the Oil Firing

Technical Association for the Petroleum Industry, the Scottish and Northern Ireland Plumbing Employers Federation and the Underfloor Heating Manufacturers Association.

Natural Stone Flooring, cope of practice for the design and installation of internal flooring, published by the Stone Federation

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Summary of necessary actions

- All underfloor heating must be tested and conditioned before tiling
- Screeds must achieve SR1 surface regularity
- Resin agglomerate tiles have a Coefficient of Thermal Expansion four times greater than ceramic tiles
- Screed must be dry (particularly calcium sulfate), flat and dimensionally stable before tile fixing
- Ensure the floor sensor is fixed before fixing the floor tiles. The floor sensor is generally supplied with the thermostat.
- Suitable normal or fast setting adhesives to minimum C1S1 classification should be used. On suspended timber a C2 S1/2 adhesive with deformable characteristics should be used.
- Tile grout must be CG2 or CG1 with suitable dispersion admix. A reaction resin grout (RG) may also be used.
- Solid bed fixing is essential
- Back buttering of large format tiles will be required
- Movement joint should extend through both the screed and tile bed dividing the tiling into areas not greater than 40sqm for ceramic tiles and 25 sqm for resin agglomerated tiles. The areas defined by movement joints should be square to rectangular with the width to length ratio not exceeding 5 to 8.
- Commission the heating system after tiling