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Wooden floors over underfloor heating

BASIC INFORMATION TRADE GUIDELINES TERMINOLOGY

This guide to good practice provides basic information about what you should think about with respect to different kinds of wooden floors over underfloor heating, how to assess the heat guidelines and what the requirements are regarding temperature, atmospheric humidity and moisture protection of wooden floors.

Underfloor heating can be used over most sub floors. Here, we describe the installation over concrete and wooden joisted floors and the regulation of the underfloor heating system.

These general trade guidelines consist of advice and instructions for the installation of underfloor heating systems and describe the constructions, which the industry considers to be suitable. The instructions also describe the documentation which is to be given to the client after the installation, and how to start-up the underfloor heating system and use the floors.

This basic information is intended for retailers, end-users and those that are considering wooden floors over underfloor heating systems. The information intends to clearly emphasize the conditions and general limitations, which are associated with these systems.

The trade guidelines are intended for builders, architects, heating, ventilation and sanitary contractors, electrical, floor and building contractors and they were originally produced for Scandinavian conditions. The guidelines are intended to clarify the application of each product and the floor-installing conditions for the wooden floor and the underfloor heating.

The terminology provides a list of concepts and designations within the field of flooring, wooden floors and underfloor heating. For each of these fields, information is given about the range of application, directions for use and comments, where appropriate.

Note, in particular, that this document provides only general recommendations. The supplier's specifically documented fitting and installation instructions always take precedence.

Stockholm, September 2005
The Swedish Flooring Trade Association, GBR

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TRADE GUIDELINES

Assessment of the heat requirement

The accompanying tables present the total power requirement for buildings built in different years in different parts of Sweden. The tables indicate general reference values for an assessment of the heat requirement.

The power requirement has been calculated for a single-storey house with a floor area of 120 m^2 (15 x 8 m) and a ceiling height of 2.5 m with the help of formulae and values used within the trade. To obtain these reference values, the total floor area has divided the total power requirement. If you have a house, which is smaller than 120 m^2, the power requirement increases and, with a larger house, the power requirement decreases slightly.

It should be pointed out that the values in the tables have not taken into consideration the houses with large heat losses, moisture in the building construction, great air leakage or, for example, poorly sealed windows or large window areas. If you are uncertain about your heat requirement assessment, it is recommended that you seek assistance from professionals with experience of heat requirement calculations. It is also possible to assess the heat requirement if you measure the energy consumption during a predetermined period (the coldest) and calculates the power requirement per m^2 (design heat flow density) from this. If the power requirement according to the heat requirement assessment or calculation is greater than that recommended for a wooden floor, additional insulation to reduce the power requirement should be considered or, alternatively, the use of another complementary heat source in order to enjoy the comfort of underfloor heating. In general, you should not install a unit with a greater power/m^2 than is necessary. If a unit with a high power/m^2 is installed, the temperature fluctuations become greater and the risk of excessive temperatures increases.

Calculation of the heat requirement
The underfloor heating system shall be dimensioned on the basis of a detailed assessment of the heat requirement, taking into consideration the following factors:

- *the area of the building, height of the roof*
- *the underfloor construction*
- *the U-values (underlying flooring, ceiling and walls)*
- *ventilation and heat recovery*
- *window areas (e.g. u-values)*
- *DUT-design outdoor temperature*
- *the indoor temperature*

The heat requirement shall be calculated separately for each house and each room, and this heat requirement calculation shall then provide the basis for the choice of underfloor heating system, design and dimensioning.

In the renovation of an old house construction, it may be difficult to make a satisfactory heat requirement calculation since the input data are not available. A specialist will however usually be able to make a rough calculation.

Take care not to install excessive power in electrical underfloor heating systems.

A wooden house power requirement W/m² floor-area

Buildling year	-1940	1940-60	1960-80	1980-90	1990-
Zon 1	75-80	60-80	45-60	40-45	35-40
Zon 2	95-100	80-90	60-70	45-55	40-45
Zon 3	100-105	85-95	65-75	55-60	50-55
Zon 4	100-110	85-95	65-75	55-60	50-55

A stone/brick house power requirement W/m² floor-area

Building year	-1940	1940-60	1960-80	1980-90	1990-
Zon 1	90-110	75-100	45-70	40-45	35-40
Zon 2	115-125	95-110	60-80	45-55	40-45
Zon 3	125-135	105-115	65-90	55-60	50-55
Zon 4	135-145	105-130	70-95	55-60	50-55

The reference values in the table are based on buildings constructed in accordance with the building standards applicable at the time of building. For underfloor heating with a floor area less than 6 m², the power requirement is slightly higher than that indicated in the table.

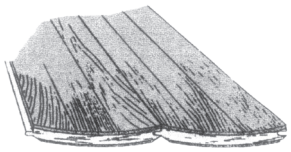
A General information about wooden floors, underfloor heating systems and conditions

Type of wooden floors:

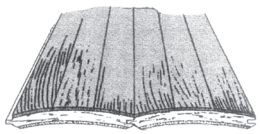
Wooden floors are available in many different varieties. The most common type of flooring consists of multi layer boards, which are installed floating on the foundation. These are normally 14 –15 mm thick, but 22 mm-thick boards are also available and they are then self-supporting. In addition to the multi layer boards, there are also solid wooden floors. The solid wooden floor concept includes several different types, such as short block parquet, planks of softwood and hardwood, mosaic parquet etc. A common feature of the solid wooden floors is that they are in most cases nailed, screwed or glued to the sub floor. Some solid wooden floors are installed floating over the underlying joist system.

Properties of wood:

Wood is a hygroscopic material with the ability to emit and absorb moisture from the surrounding air and materials. The result is that the wood "lives" or, in other words, it swells and shrinks in size, depending on the atmospheric humidity. The moisture ratio of the wood strives to maintain equilibrium with the surrounding climate. During dry periods, gaps often arise between boards, and "dishing" occurs. During moist periods, on the other hand, the boards press tightly together and a slight "cupping" can occur.



Dishing (concave)



Crowning (convex)

It is best for all wood-based materials if the relative humidity, RH, in the room can be kept between 30 – 60% both **during** and **after** installation. At a relative humidity lower than 30%, more and larger gaps arise than is normally acceptable. On the other hand, if the relative humidity exceeds 60%, permanent deformations in the material can arise, and this can also influence the fitting of the wooden floor against the sub floor and can damage glued joints etc. The relative humidity is thus decisive for both the function and the appearance of the wooden floors.

Normally, underfloor heating leads to a slightly lower relative humidity immediately above the floor surface, since the air temperature at the floor level is higher than that in the rest of room and warm air can contain more moisture than cold air. In a space with an RH of 30% at 20°C, the relative humidity drops to ca. 20% at 27°C, unless the total moisture content of the air is changed.

Different floor materials feel more or less warm or cold at the same temperature, if the floor surfaces in contact with some part of the human body have different thermal conductivities, i.e. if the surface material conducts or insulates the body heat more or less efficiently. Wood is a relatively heat-insulating material. In certain contexts, a heat-insulating material is desirable but in other contexts, e.g. in underfloor heating, a material with a low heat transfer resistance (a less heat-insulating material) is preferable.

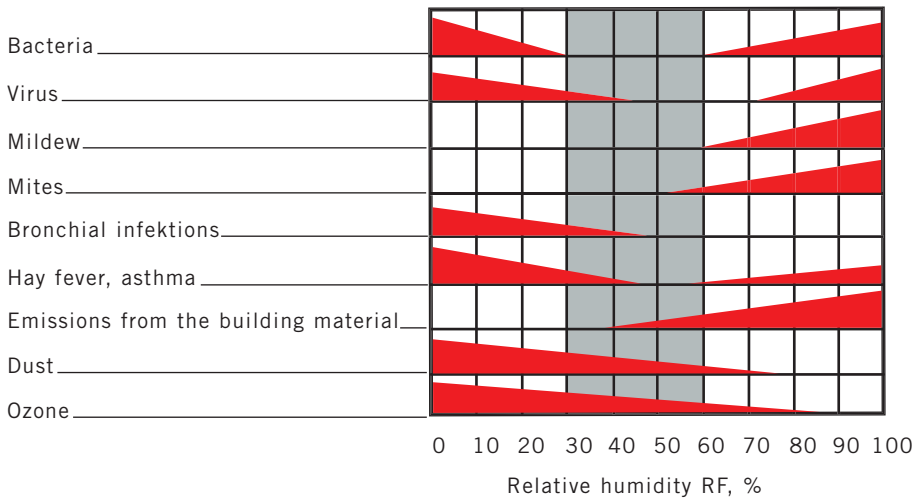
It is generally considered that tiles, due to their low heat transfer resistance, are more suitable over underfloor heating than wood. At the same time, tiles can feel cold to walk on if the underfloor heating is switched off. In contrast, wood does not conduct the heat away as rapidly and it therefore feels warmer. The result is that the underfloor heating is often switched on for a longer period of the year with a tile floor than with a wooden floor.

A correct relative humidity, RH, is good for both wooden floors and human beings

It is not only wood-based floor materials that thrive at an RH between 30 – 60%. We humans also prefer our indoor air to have a relative humidity within these limits, as is evident in the Healthy House-project's diagram showing the importance of the indoor air humidity.

HEALTHY HOUSES

The diagram shows the importance of the indoor air humidity



The height of each coloured sector is proportional to the occurrence of the differnet pollutants or risks.

(Source:BRF-report R113:1989)

Types of wood:

In multi layer parquet, Beech and Hard Maple (Canadian maple) shrink and swell more than other wood types. Underfloor heating leads to further drying and this causes further shrinkage. In a cold dry climate such as that in Sweden, gaps can therefore appear between blocks and between boards. In Scandinavia and other countries with a similar climate, these types of wooden floor are therefore considered to be unsuitable for underfloor heating. However, some manufacturers produce Beech and Maple wooden floors, which have been manufactured with a special drying method called press drying. This drying method degrades about 60% of the wood cells and this reduces the wood's ability to move. After this treatment, the Beech and Hard Maple wood types are also suitable for use over underfloor heating.

Solid or multi layer wooden floors:

Most types of wooden floors are well suited for installing over underfloor heating.

Solid wooden floors, however, always have a greater tendency to move, regardless of whether or not the floor is installed over underfloor heating. The size of the gaps, which develop, depends largely on the breadth of the block or board. Narrow blocks give a small gap, and broad boards give large gaps, but the underfloor heating in itself does not cause the gaps to become larger. You should expect shrinkage of about 1% of the width of the board under (30 – 60%) conditions. However, be prepared for the fact that individual boards of a solid wooden floor can always move more or less. On solid small parquet blocks, the gaps that develop are very small.

Multi layer wooden floors can also develop gaps, but the construction of the floor makes these very small. The gaps arise between boards and not between blocks.

Underfloor heating systems:

There are two types of underfloor heating system: hydronic and electrical.

In a ***hydronic*** system, the heating water is circulated in pipes, which are installed at suitable distances beneath the floor in the room from which heating is to be provided. The water temperature is varied depending on the floor construction and on the heating requirement in the room. In general, the maximum supply water temperature should be about 50°C. The normal supply temperature is between 30 and 40°C. When the water has circulated through the pipes, the temperature has decreased slightly. The extent of this decrease depends on the sub floor insulation, ventilation, windows etc. The water can be heated with various heat sources such as a heat pump, electricity, oil, solar energy etc.

In an ***electrical*** system, an electric current is sent through a conductor. Heating cables are made of a conductive material with a high resistivity and this produces heat. The temperature in the floor is then regulated with the help of a thermostat. Heating cables or so-called heating foils are available with a constant or a self-regulating effect.

Regulation of hydronic underfloor heating:

For a hydronic system to function, all the components must function together and the system must be built up so that both the heat source and the underfloor heating system function in an optimal manner. In addition, the heating system must be correctly balanced so that the water flows are distributed in the way intended.

The system can usually be regulated by varying the water temperature, the water flow or both. The regulation usually takes place in two stages, by varying the temperature of the water to the underfloor heating manifold and by varying the temperature and/or flow in the separate underfloor heating coils. If the underfloor heating system is responsible only for heating in a part of the building and the other parts are heated with a system of radiators, the water temperatures towards the two systems must usually be controlled separately. Usually, new radiators require 55°C (old houses with radiators require an even higher temperature) when it is coldest outdoors, whereas underfloor heating requires a temperature about 15°C lower than this.

There are normally three ways of regulating the water temperature in a hydronic underfloor heating system: manual shunting, constant/max limitation of the in-flow temperature or outdoor-temperature-compensated regulation.

Manual regulation usually takes place with a shunt valve, where the mixing of return water from the heating system and the supply water from the heat source is set manually. This requires room controls and preferably also a maximum limit!

A constant/maximum limitid supply temperature is often attained with the help of a thermostat and a sensor which senses the temperature of the water going to the underfloor heating system and maintains the set value by mixing the warm water from the heat source with the return water from the underfloor heating system – but not above the set value. If the temperature from the heat source is below the set value, no mixing of the return temperature takes place, and water at the temperature of the heat source goes directly to the underfloor heating system. This requires room regulation!

The principle of outdoor temperature compensated control is that an outdoor sensor for the temperature is linked to the regulator. The regulator mixes water from the heat source with the return water from the underfloor heating so that the input temperature follows a curve that relates the water temperature to the outdoor temperature. This requires a maximum limit and preferably room regulation.

If the underfloor heating is intended only for comfort, and if the main heating is provided by e.g. radiators, it is also possible to choose to keep the return temperature of the coils constant. This means that the floor temperature is kept more or less constant. In order to avoid the risk that the underfloor heating takes over too large a part of the heating or that the floor becomes overheated if the radiator system is shut off, the control should be complemented with a low setting of the maximum limit of the supply temperature. In this case, the room temperature is regulated with the radiators.

The valve that mixes the warm and cold water is usually called a shunt valve. Shunts are available in different designs, and three-way or four-way valves are the most common. The aim is the same, i.e. to mix different amounts of water having different temperatures. Shunts can be built into the heat source (the boiler, heat pump, heat exchanger etc), separately between the source and the underfloor heating manifold or integrated with the underfloor heating manifold.

In most cases, the control of the input temperature to the underfloor heating manifold is combined with individual room control, where room thermostats regulate the water flow in the different coils. The room thermostat is connected via an actuator, which has been fitted to the manifold. The actuator opens and closes a valve that influences the flow in the coil. There are also thermostats with floor sensors, which prevent the floor temperature from becoming too high.

It is important to make sure that the different rooms are really being heated by the coils in the room and not by coils in adjoining rooms. In an open layout, it may be suitable to let all the coils be controlled from a centrally placed thermostat, to avoid the risk that the coils controlled by the thermostat which first calls for heat will in reality also heat the adjoining parts.

With wooden floors, a surface temperature higher than 27°C is not permitted. This applies also under rugs and other coverings.

Regulation of electrical underfloor heating:

Electricity is usually supplied to the heating element on an on/off-basis via the thermostat that is linked to floor and room sensors. A thermostat with a floor sensor is used to keep the floor temperature constant. Room thermostats (with floor sensors as overheating protection) are used to keep the room temperature constant. A manual adjustment is usually required between the seasons, depending on the insulation of the building. Since the sensor only measures the temperature in the area in which it has been placed, it does not sense areas, which are covered. The heating ceases if the sensor is covered. On the other hand, if other floor surfaces are covered, the heating continues and the temperature in the construction under the covering increases.

Constant power means that the heating cable or foil emits the same power along the whole coil, whether it is covered or not. If the floor surface is covered, the temperature of the covered surface can, however, still exceed the allowed 27°C.

A self-regulating system is a system that locally adapts its power according to the surrounding heat requirement. If the surface is cooled, the power increases and if the surface is covered, the power decreases. However, the temperature under a covered surface can still exceed the allowed 27°C.

It is therefore important to point out that the temperature is in general higher under rugs than around them.

With wooden floors, a surface temperature higher than 27°C is not permitted. This applies also under rugs and other coverings.

Conditions:

If the underfloor heating is to function properly, it is extremely important that the insulation of the underlying joist floor is sufficient and is correctly installed. If an underfloor heating system is placed over an uninsulated foundation, a large part of the heat can be lost downwards. The dimensioning of the system is also important.

The heat requirement in a poorly insulated building can be so great that it is not possible to supply the whole power requirement via the floor without the surface temperature on the wooden floor becoming too high. In such cases, the underfloor heating must be continued with other heat sources such as radiators or a stove.

Underfloor heating is often installed as the sole heating system in new constructions. The installed power, regardless of the type of system, must then meet the heat requirement of the room during the coldest period. This heat requirement is calculated on the basis of how much heat disappears through the ceiling, walls, windows, ventilation etc. Problems can sometimes arise with large window sections, where the downdraught effect can dominate when the outdoor temperature is low. Warmer edge zones/peripheral areas or other assistant heat sources can perhaps compensate this. In electrical underfloor heating, any such edge zones/peripheral areas shall be provided with their own floor sensors.

Underfloor heating can of course also be installed in combination with already existing radiators that meet the heat requirement of the room. This is often called comfort heating. In such cases, it is important not to over-dimension the underfloor heating power and as such give temperatures, which are too high.

To obtain the desired result on the heated surface, electrical underfloor heating can be placed in different ways, depending on the type of cable or foil, the power per metre of the cable or per square metre of the foil, the length of the heating cable per square metre and the type of floor construction. It is important for a wooden floor (and for comfort) that the heating system is designed so that it gives a very uniform surface temperature over ***the whole floor surface.***

B The foundations

Underfloor heating can be used in principle on all types of sub floors, but it is important to choose an underfloor heating system that is adapted to the sub floor and the wooden-floor construction.

Wooden joisted floor:

Hydronic underfloor heating can be placed in heat emission plates hanging between the beams, or alternatively lowered between secondary spaced boarding or placed in a grooved underfloor heating particleboard. The function of the plates is to "spread" the heat from the underfloor heating pipes in a suitable manner to give a uniform temperature on the floor surface. Thereafter, the wooden floor is, if possible, placed directly over the underfloor heating without further board materials but with a vapour barrier, in accordance with the floor supplier's instructions. All the wood material in beams and secondary spaced boarding shall have moisture content of max 10%. Boards etc shall have moisture content of max 9.5%.

When electrical underfloor heating coils are installed, the underlying wooden joisted floor shall first be covered by a particleboard placed on top of or lowered between the joists. The electrically conducted underfloor heating is placed on the particle-board in accordance with the manufacturer's instructions.

NOTE! It is important that the insulation in the joists is sufficient to limit the downward losses and that there are no air-gaps between the contact surfaces of the heat emission plates and the overlying material. In hydronic systems, it is also important that the heating coils are as close to the wooden floor as possible in order to facilitate a rapid and effective heat transfer through the wooden floor.

In wooden joisted floors, there must be no air gaps between the insulation and the beams or between the insulation and the underfloor heating installation.

Concrete sub floor:

In a new construction with adequate underlying insulation, the underfloor heating coils can be cast into the concrete base or be placed on an already cast concrete in a screed mix. Concrete conducts heat well, and heat emission plates are therefore not required. A vapour barrier, rag felt and the wooden floor are placed on the concrete surface. If an impact sound insulation with respect to an underlying room is required, an acoustic damping floor covering shall be used (not rag felt). Solid wooden floors can be screwed or nailed onto plywood, which is placed floating on the rag felt and vapour barrier. This construction gives a building height of 28 – 43 mm.

Note, however, that this can give rise to a need for very high supply temperatures which means that good heating insulation is required in order not suffer great down-wards losses. Another alternative is to install the heating coils on supports above a 1.8 mm impact sound insulating floor covering. This construction gives a total building height of 15 – 23 mm.

On an existing concrete floor, directly on the ground, with or without insufficient underlying insulation, insulating polystyrene boards with grooves and plates should be placed under the underfloor heating coils. There are also thin insulating boards, on top of which underfloor heating foils (electrically conducted underfloor heating) can be placed. All these systems make it possible to install a floating wooden floor directly on top of the underfloor heating. A damp proof membrane is usually placed beneath the insulating boards (NOTE! A damp proof membrane must not be mistaken for a vapour barrier).

Foundation and moisture:

Insufficient insulation together with underfloor heating installed in a concrete slab on the ground or in a cellar leads to the risk that the underlying ground will be heated. During cold periods, the foundation then is heated downwards towards the underlying ground. When the heating is shut off during warm periods, the slab cools and, if the insulation is thin, a reverse moisture migration can arise, i.e. from the underlying ground to the concrete slab. To prevent this, the insulation must be increased or the underfloor heating must be left switched-on with a low basic temperature.

Moisture protection:

If a wooden floor is installed over underfloor heating there shall always be a vapour barrier in the construction as close to the wooden floor as possible.

Parquet floors must always be protected from moisture from the sub floor. This applies as soon as moisture is suspected or when it is known that the relative humidity (RH) in the sub floor is higher than 60% RH. Moisture protection in the form of a vapour barrier is compulsory when the sub floor consists of a floor on the ground, light concrete beams, a floor above a permanently warm or humid premises, e.g. a boiler room, a wash house or the like, warm floors (underfloor heating) or a joisted floor over a ventilated crawl space foundation.

Note that the vapour barrier is always placed under any rag felt or impact sound damping floor covering. A vapour barrier shall be used under solid wooden floors if it suspected that the sub floor might transport moisture, e.g. a slab on the ground.

Types of moisture protection:

A vapour barrier can be provided by a ca. 0.2 mm thick ageing-resistant polyethylene plastic film, which controls the transport of water vapour. This is the most common type of moisture protection and it is sufficient in most cases.

A damp proof membrane is a 2 – 10 mm profiled plastic mat, which creates air gap prevention for the transport of water vapour and capillary suction. The damp proof membrane is normally used in e.g. cellar spaces or on a slab on the ground, where there have previously been problems with moisture and/or odour.

Note! Before installing underfloor heating and wooden floors in an existing house (renovation), the cause of any moisture problem should be identified and solved. The risk of future moisture problem, e.g. due to higher ground temperatures as a result of the underfloor heating, must also be taken into account.

Always contact a specialist to determine the right moisture protection.

Sub floor constructions and energy consumption:

It is important to emphasize that, even if two rooms are identical above floor level and thus require the same surface temperature on the floor to provide the heat requirement "above the floor level", the losses downwards, and thus the total heat consumption, can vary. It is obvious that a poorly insulated joisted floor leads to greater losses than a well-insulated one. If, in addition, the actual wooden floor is more insulating (e.g. very thick), higher electric power and higher water temperatures will be required to achieve the correct surface temperature, and this further increases the downward losses.

C Planning

Before underfloor heating is installed, it is important to analyze the structural engineering conditions in the building. The planning can then include the direction in which the coils are installed, solutions for acoustic damping and possible drying times. Specifics must be taken into account, for example, large glass sections, which even though they may have a relatively good insulating ability, may require high power locally.

The total heat requirement and the power requirement per square metre are determined in a thermo-technical dimensioning analysis. In the case of total heating, the power of the heating floor should correspond to the heat requirement. One has to avoid over-dimensioning the power in electrical heating, since this can lead to high excess temperatures on the floor surface. In the case of partial underfloor heating, the heating floor supplies part of the heat requirement, and this means that supplementary heating equipment with the necessary power should be available in order to avoid a drop in the indoor temperatures during cold periods.

Renovation:

In the case of renovation, the most common procedure is that the light underfloor heating system is placed either on the joisted floor or in a wooden joisted floor. In old buildings, it is extremely important that a heat dimensioning calculation is made. The possible need for additional insulation of the joisted floor should be investigated. For a joisted floor on the ground, the moisture conditions should be mapped out and suitable measures should be proposed, e.g. a damp proof membrane or a new drainage system. In underfloor heating in a cellar, the risks of moisture in the cellar walls must also be taken into consideration.

New constructions:

New buildings are normally so well insulated that an underfloor heating system can provide total heating, but the construction of a floor on the ground or on top of a crawl space foundation must always be inspected to ensure that there is sufficient insulation for underfloor heating. Often, there are building drawings, which provide a good basis for estimating of each room's heat requirement.

D Start and operation

Start:

A wooden floor shall always be installed under controlled conditions, this means with a room temperature of approximately 20°C (± 2°C) and a relative humidity between 30 and 60% RH. As such that the underfloor heating need not be in operation as long as the room temperature and atmospheric humidity are kept within these limits. The underfloor heating system is started up in accordance with the manufacturer's instructions.

Total function:

The total function of an underfloor heating unit must take into consideration e.g. load-bearing capacity, impact sound reduction, heating and the function of the surface materials in the operating stage. A number of examples of these functions are given below.

Normally, *the load-bearing capacity* of a joisted floor is not a matter of concern. However, in certain cases when underfloor heating coils are placed in heat emission plates in secondary spaced boarding it has become a concern, since the dimensions of the secondary spaced boarding are decisive for the load-bearing capacity of the wooden floor, which is placed on the secondary spaced boarding. If the wood is too thin, springiness can arise in the wooden floor.

Acoustic damping is a functional question, which is of interest only if the joisted floor constitutes the ceiling of the underlying room or apartment. If the underfloor heating in this situation is cast into the joisted floor, acoustic-damping mats with a thickness of 2 – 3 mm must be installed to reduce the sound of steps.

For *the heating to function* effectively, a good underlying insulation is required. This ensures that the heat losses downwards (i.e. in the wrong direction) are not too large, and this helps to keep the energy consumption and operating costs as low as possible.

The function of the surface material involves movements between boards or parquet blocks, movement between the wooden floor and sub floor and resonance sounds (i.e. sounds, which arise in the same room, such as steps from a person walking in the room).

Surface temperature limitations:

A common feature of all the wooden floors on the market today is that they allow a maximum surface temperature of 27°C. In most cases, such a high surface temperature will be needed only in exceptional cases during cold and dry periods, but experience says that during this period, the relative humidity decreases drastically.

However, it is important to emphasize that, even without underfloor heating, it is usual for the atmospheric humidity to drop below 30% RH during cold periods. One solution can be e.g. to reduce the ventilation and perhaps to install an air humidifier. In summertime, the temperature of the floor surface is often higher e.g. when the room temperature rises or when the sun shines in through a window but, since the RH is considerably higher during the summer, this does not influence the wooden floor in the same way.

Atmospheric humidity:

As has been stated previously, it is the relative atmospheric humidity (RH) that is in principle completely decisive for the appearance and movements of the wooden floor and, in the long run, also its function. A wooden floor, which is subjected to very low or very high atmospheric humidities, will shrink and swell beyond the limits indicated by the manufacturers. It is important to understand that these limits are set not only from an aesthetic viewpoint.

Extensive movements in a wooden floor affect the glued joints and the fitting against the sub floor, and they give rise to movements between the surface layer and the frame of the wooden floors. In addition, there are more simple everyday consequences, such as dirt settling in gaps and subsequently preventing the wooden floor from closing together when it swells in a high atmospheric humidity.

Coverings:

In the great majority of homes, rugs are placed on wooden floors. Such rugs have a negative effect on the underfloor heating system. Remember that an underfloor heating system is never dimensioned on the assumption that the floor surface will be covered. The total heat requirement of a room is calculated in W/m^2.

If half the floor surface is covered by an additional material with a low U-value the heat requirement of the room will not be reached. It is therefore recommended that one avoid covering large areas of the floor with rugs. Even a bed with a covering base or a bookcase must be regarded as a covering unless it is ventilated.

It is also important to point out that the temperature under a rug or the like is normally higher than on the surrounding surfaces. On wooden floors, higher surface temperatures than 27°C are not permitted and this also applies under rugs etc.

Operating stage:

Always follow the underfloor heating supplier's instructions with regard to the operation and maintenance of the underfloor heating system, and the operating instructions from the wooden floor supplier.

Whether or not the underfloor heating system shall be switched-on all the year round depends on the foundations and the risk of so-called reverse moisture transport. You should therefore always consult a specialist regarding the design of the foundation, and the underfloor heating supplier as to whether or not the system can be shut off.

Cleaning:

Always follow the wooden floor supplier´s instructions regarding the cleaning and maintenance advice for varnished, oiled and UV-oiled wooden floors.

A General conditions

Wooden floors:

The maximum permitted surface temperature is 27 °C. This also applies under rugs and furniture.

Wooden floors with a multi layer construction and a surface layer of Beechwood or Maplewood shall not be installed over underfloor heating.

There must be no air gap between the underfloor heating and the wooden floor.

Wooden floors shall always be protected against underlying moisture with either a damp proof membrane or a vapour barrier.

The heating system shall be designed so that it gives a very uniform surface temperature over the whole floor area.

Sub floors:

The sub floor shall be free from dirt, dust and loose particles.

When a board material is installed, the evenness of the sub floor shall conform to the manufacturer's requirements.

Wooden beams and secondary spaced boarding shall have a moisture ratio not exceeding 10%.

Wooden-based board materials, MDF, particleboards and plywood boards shall have a moisture ratio not exceeding 9.5%.

Secondary spaced boarding placed on top of a wooden joisted floor with a centre distance of 600 mm shall have a thickness of at least 28 mm.

Old flooring materials such as plastic and linoleum coverings should be removed before an underfloor heating system is installed. Note that when old carpets are removed, the acoustic damping may be affected.

Consideration shall be given to the underlying rooms with regard to the need for acoustic damping.

Insulation:

When underfloor heating is installed, the quality of the underlying insulation and the total insulation of the building/house must be taken into consideration.

The higher temperature in an underfloor heating joisted floor should be compensated for with a thicker insulation.

If underfloor heating is placed over an intermediate floor of concrete, the joisted floor shall be insulated to avoid "ceiling heating".

A foundation slab on the ground shall always be insulated. In Sweden, the minimum insulating thickness is 200 mm.

In a wooden joisted floor, there must be no air gaps between insulation and beams or between insulation and underfloor heating installations.

Moisture:

If a wooden-based material is installed over concrete with a humidity of **up to** 95% RH, a vapour barrier should be used.

If a wooden-based material is installed over concrete with a humidity of **more** than 95% RF, a damp proof membrane should be used.

NOTE! Before the installation of underfloor heating and wooden floors in existing houses (renovation), the reason for any moisture problem, particularly in joisted floors above crawl space foundations and in cellars, should be analyzed and solved.

Dimensioning and heat requirement:

If a wooden floor is installed over underfloor heating, a maximum design floor surface temperature of 27°C applies, and this corresponds to ca. 75 W/m^2 for a room temperature of 20°C.

Heat requirement calculations:

The underfloor heating system shall be dimensioned on the basis of a detailed calculation of the heat requirement. The heat requirement is assessed on the basis of the following factors:

- *the area of the building, room height*
- *the sub floor construction*
- *U-values (support plus ceiling and walls)*
- *ventilation and heat recovery*
- *window sections (e.g. U-values)*
- *type of floor and the thickness of the wooden floor*
- *DUT-design outdoor temperature*
- *the indoor temperature*

The heat requirement must be calculated individually for each house and room and this heat requirement calculation shall then provide the basis for the choice of underfloor heating system, its construction and its dimensions.

In the case of a renovation of an old house, it may be difficult to make a satisfactory heat requirement calculation, since the required input data may not be available. A specialist can then make a standard type of calculation.

Avoid the installation of excess power in electrical underfloor heating systems.

Coverings:

Note that whenever a covering is placed on a wooden floor installed over underfloor heating, there is a risk that:

- the temperature limits for the wooden floor will be exceeded
- the temperature in the room will be too low

Coverings include rugs, beds without a ventilated base, bookcases with a covering base, kitchen cupboards etc.

B Choice of construction and projecting

Hydronic systems:

The flow lines of the coils shall, as far as possible, be placed against external walls, sections with large windows or against surfaces with a greater heat requirement than others. If edge zones/peripheral areas are used in sections with large windows or in regions with a greater heat requirement than others, it is important that the underfloor heating temperature is kept uniform across the whole floor surface and that the floor surface temperature does not exceed 27°C. In order to ensure this, the edge zones/peripheral areas can be installed with separate coils.

The underfloor heating manifold should be placed centrally to give short supply pipes, and so that the connected coils do not unnecessarily pass expansion joints. Long supply pipes installed in concrete (in rooms other than those which are to be heated by the coils) should be insulated.

Designing the coil lengths is done dependent on the temperature drop and pressure drop, on the heat requirement and on the capacity of the circulation pump. Note the maximum coil length, however. If the coils are placed in a helical pattern or in a parallel run, the length can be increased after consultation with the manufacturer.

In a hydronic underfloor heating system, the circuit should be designed for a temperature drop of 5 – 7°C.

The manufacturers' instructions with regard to the longest and shortest coil spacing and the coil depth in concrete shall be observed.

If underfloor heating is installed in a wooden joisted floor or in grooved boards etc, consideration should be given to the direction of the coils in relation to the intended direction of the wooden flooring. In systems with heat emission plates, it is important that a sufficiently large area is covered with plates.

Electrical heating systems:

The underfloor heating system shall at least be CE-marked and shall meet the requirements of the current electric regulations.

Each underfloor heating system shall be regulated with its own thermostat with a floor sensor. The underfloor heating can not be regulated with a room sensor alone. A combination of a room sensor and a floor sensor is however possible.

If edge zones/peripheral areas are placed by large window sections or in other regions with a greater heat requirement than the other regions, it is important that the underfloor heating temperature is kept uniform across the whole floor surface and that the floor temperature does not become higher than 27°C. In order to ensure this, the edge zones/peripheral areas shall be installed with separate heating systems and shall have their own thermostats with floor sensors.

The manufacturers' instructions for coil depth and centre-to-centre distances in concrete shall be followed. When solid wooden floors are fixed through the foundations, consideration shall be given to the direction of the coils in relation to the intended direction of the wooden floor.

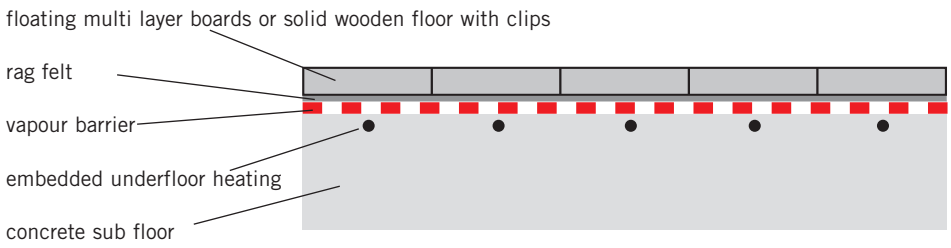
Joint construction solutions for the industry for underfloor heating joisted floors:

1. Underfloor heating cast into concrete or placed in screed compound. Slab on the ground or intermediate floor.

The concrete floor is covered with a vapour barrier (ageing-resistant plastic) and thereafter rag felt. The vapour barrier shall overlap by at least 200 mm. Rag felt shall not overlap unless levelling is required. The rag felt can be installed in up to three layers for levelling. If the levelling should require more than three layers, levelling with a screed compound is recommended instead.

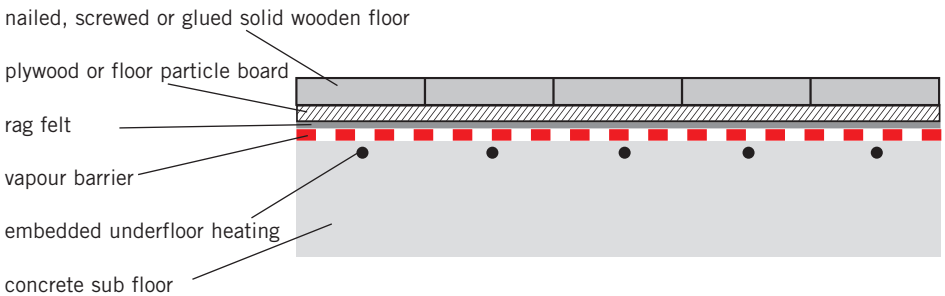
- Multi layer boards are installed floating.
- Solid wooden floors are installed floating with clip supports

Fig 1A



- Solid wooden floors are nailed, screwed or glued onto plywood boards or floor particleboards which are installed floating. House AMA KEB.234, 2341, 2342, KEJ 234. Note: The construction requires water with a high supply temperature or high electric power to reach the maximum permitted surface temperature.

Fig 1B

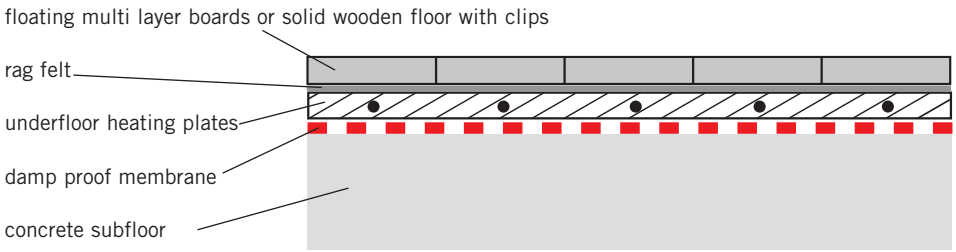


2. Underfloor heating in floating underfloor heating plates (styropore) with heat emission plates etc over a slab on the ground, in a cellar or over an intermediate floor.

A damp proof membrane is placed under the underfloor heating plates. Rag felt is placed over the underfloor heating plates.

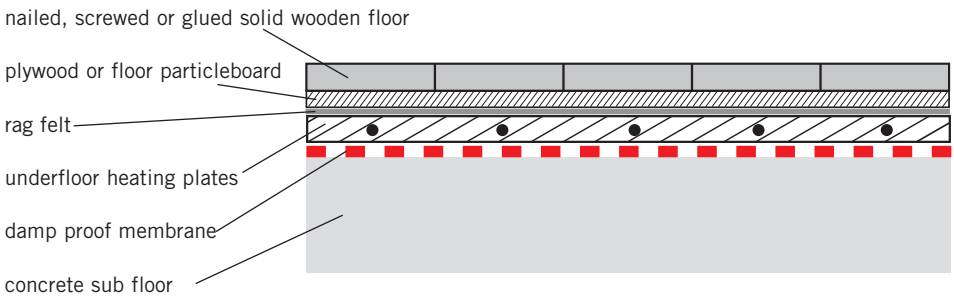
- Multi layer boards are installed floating, normally across the coils.
- Solid wooden floors are installed floating with clip supports, normally across the coil.

Fig 2A



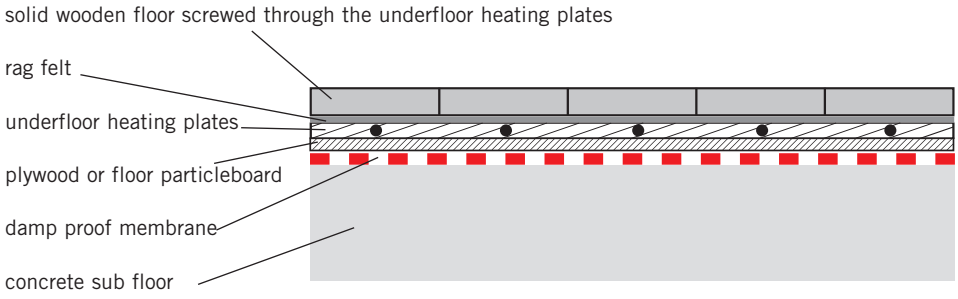
- Solid wooden floors are nailed, screwed or glued onto plywood boards or floor particleboards which are installed floating. House AMA KEB.234, 2341, 2342, KEJ 234. Note: The construction requires water with a high supply temperature or high electric power to reach the maximum permitted surface temperature.

Fig 2B



- Solid wooden floors are screwed through the underfloor heating plates and down into the underlying slabs of the wood. (A damp proof membrane is placed on the slab and thereafter a plywood or particleboard). The underfloor heating plates and rag felt are placed over the slabs of the wood. Solid wooden floors are screwed through the underfloor heating boards and down into the slabs of the wood. The screw must not penetrate and puncture the damp proof membrane. Note: the underfloor heating plate should be not more than 15 mm thick.

Fig 2C

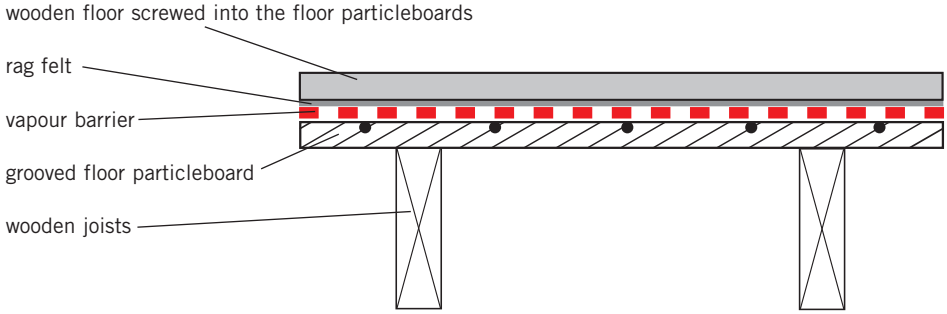


3. Underfloor heating in grooved floor particleboards with heat emission plates over wooden joists.

The floor particleboards are covered with a vapour barrier (ageing-resistant plastic) and thereafter rag felt. The vapour barrier shall overlap by at least 200 mm. Rag felt shall not overlap.

- Multi layer boards are installed floating, normally across the coils.

Fig 3A
floating multi layer, solid wooden floor with clips or solid wooden floor screwed into the floor particleboards



- Solid wooden floors are screwed into the floor particleboards. The wooden floor is installed perpendicular across the underfloor heating coils. The placing of the under-floor heating coils shall be marked on the rag felt to avoid damage to the coils.

- Solid wooden floors are installed floating with clip supports.

4. Underfloor heating in secondary spaced boarding installed over or lowered between floor joists with a centre-to-centre distance of 600 mm.

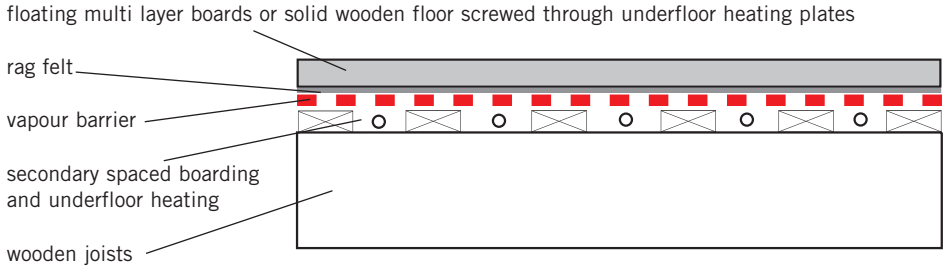
The secondary spaced boarding is covered with a vapour barrier (ageing permanent plastic) and thereafter rag felt. The vapour barrier shall overlap by at least 200 mm. Rag felt shall not overlap.

- Multi layer boards 14 – 15 mm are installed floating over secondary spaced boarding, which are at least 28 mm thick. The distance between the secondary spaced boarding must not exceed 30 mm.

- When installed over secondary spaced boarding which are lowered between the battens, a self-supporting multi layer board, at least 22 mm thick, shall be used. The thickness of the lowered secondary spaced boarding shall be sufficient to support the heat emission plates so that these are in contact with the multi layer floor without an air gap.

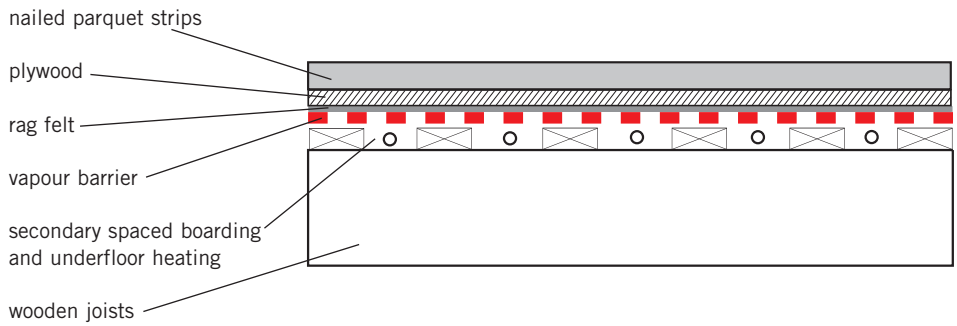
- Solid boards are screwed into the secondary spaced boarding.

Fig 4A



- Solid board parquet is nailed into plywood, at least 9 mm thick, which has been screwed into the secondary spaced boarding. The placing of the underfloor heating coils shall be marked on the plywood boards to avoid damage to the coils.

Fig 4B



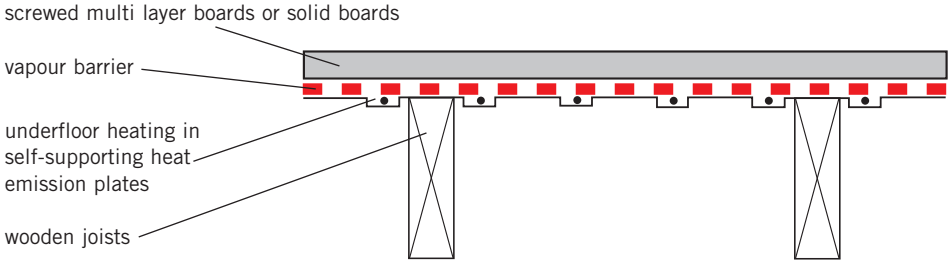
5. Underfloor heating located in self-supporting heat emission plates hanging between wooden joisted floors.

The underfloor heating is covered with a vapour barrier (ageing-resistant plastic). The vapour barrier should overlap by at least 200 mm.

- Multi layer boards: Nailing or screwing in accordance with the manufacturer's instructions. Note, only self-supporting multi layer boards applicable.

- Solid boards are screwed into joists.

Fig 5A

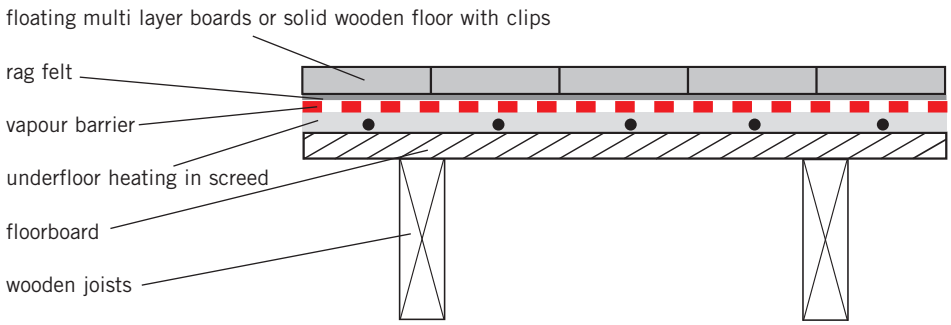


6. Underfloor heating in screed compound over floor particleboard or gypsum board over intermediate wooden floor

The floor is covered with a vapour barrier (ageing-resistant plastic) and thereafter rag felt. The vapour barrier shall overlap by least 200 mm. Rag felt shall not overlap unless levelling is required.

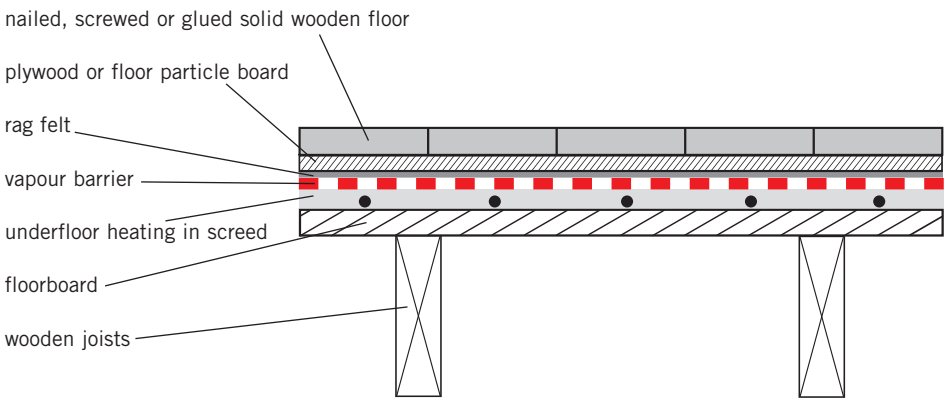
- Multi layer boards are installed floating.
- Solid wooden floors are installed floating with clip support.
- Solid boards are screwed through the plastic filler layer into the underlying floor particleboard. (Coils/heating cables shall be marked to avoid damage). It is recommended that the plastic filler layer shall be 10 mm thick, but the manufacturer's instructions take precedence.

Fig 6A



- Solid wooden floors are nailed, screwed or glued onto plywood or floor particleboards, which are installed floating. House AMA KEB.234, 2341, 2342, KEJ 234. Note: The construction requires water with a high supply temperature or high electric power to reach the maximum permitted surface temperature.

Fig 6B

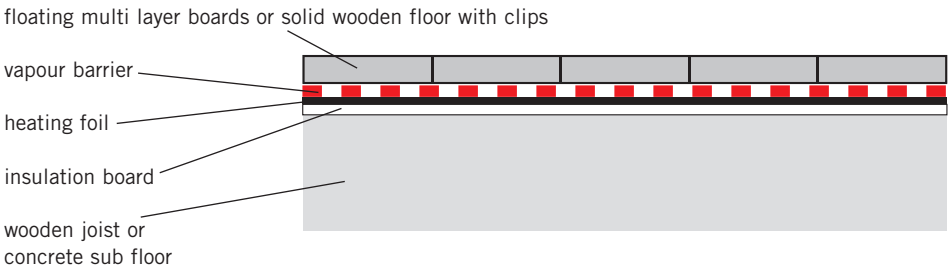


7. Heating foil, loosely installed over insulating boards (electrical underfloor heating)

The floor is covered with insulating board, thereafter underfloor heating foil and finally a vapour barrier (ageing-resistant plastic). The vapour barrier should overlap at least 200 mm.

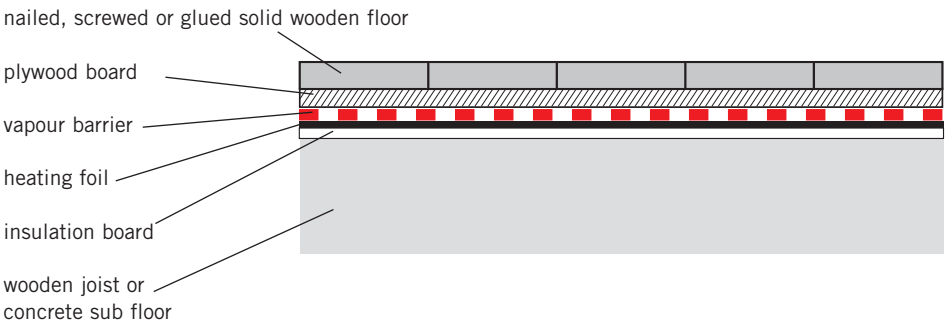
- Multi layer boards are installed floating.
- Solid wooden floors are installed floating with clip support.

Fig 7A



- Solid wooden floors are nailed, screwed or glued onto plywood boards, which are installed floating. House AMA KEB.234, 2341, 2342, KEJ 234. This installation usually requires an underfloor heating foil with a higher power than normal to attain 27°C. Note: The construction requires high electric power to reach the maximum permitted surface temperature.

Fig 7B



C Installation

The manufacturer's warranty presupposes that the instructions are read and followed carefully.

Advice and instructions

General

Coils/heating cables should be marked to avoid damage.

Plastic pipes and electric cables should be kept in a warm place during the cold season to make the installation easier. Plastic pipes shall be kept in their packaging for protection against sunlight, mechanical damage and soiling.

Wood-based materials should be temperature-conditioned in their packaging before installation.

Reinforcing net must not be installed directly against the insulation.

System boards are placed in bonds with displaced edge joints.

The coils are installed without joints.

Hydronic heating systems:

The maximum distance between the points where the coil is fixed to the reinforcing net is 750 mm.

The maximum distance between the points where the coil is fixed to the reinforcing net in bends is 200 mm.

When underfloor heating coils are installed in grooved boards with heat emission plates, the grooves shall be cleaned before the coils are fitted.

Grooved underfloor heating particleboards should be installed with displaced joints, which are placed on top of a floor joist or supported with a noggin.

Special protective pipes (conduits) or pipe insulation shall be provided where the coils pass the expansion joint of the concrete slab.

The coils shall be marked with a coil number, service area etc directly when they are fitted. The coil length is compared with the prescribed length and any deviations are noted.The underfloor heating manifold should be fitted higher than the underfloor heating installation.

The positions of the coils shall be documented carefully before they are concealed. This can be done through a scale drawing or a photograph.

The coils are flushed separately with water under pressure until all the air is displaced.

Pressure testing, according to the manufacturers instructions, should be carried out while the coils are fully visible. This pressure testing shall be documented and appended to the documents for operation and maintenance. The coils should normally be water-filled and pressurized when they are covered, i.e. when they are embedded or covered with flooring.

The concrete should have a low viscosity and must be vibrated so that no air pockets are formed. It is important that the whole coil is surrounded by concrete to prevent air pockets from being formed which lead to poor heat transfer.

The flow in the separate coils and the total flow to the manifold shall be balanced. This balancing shall be documented and appended to the documents for operation and maintenance.

A functional control of the room regulation (room thermostats and actuators) has to be carried out and documented by a professional. The room regulation shall be documented and appended to the documents for operation and maintenance.

If a thermostat is installed, it is recommended that the room sensor is fitted about 1.5 metres above the floor level on an internal wall and on a representative surface for the room. It must not, for example, be placed where it can be exposed to sunlight, close to an open fireplace or the like.

A floor sensor shall be placed in a representative position, which shall be documented on a drawing.

Electrical systems:

Electrical underfloor heating systems under a wooden floor or other flooring materials must be carried out as a fixed installation in accordance with currently valid electricity regulations.

Note the difference between series-resistive and parallel-resistive (self-regulating) electric heating cables with respect to cutting. Series-resistive heating cables must not be cut or crossed, unless otherwise stated by the manufacturer. Cutting means that the power in a series-resistive electric heating cable increases and thus also the temperature.

An electrically conducted underfloor heating system needs to be tested on resistance and insulation **before** the installation. This has to be documented by an electrician. The electric heating cable needs to be able to emit heat over its whole length and must not come into contact with the insulation.

An electrical underfloor heating system has to be fastened/anchored so that it is not moved from its determined position during the actual installation.

The maximum distance between the fastening points of the electric cable on a reinforcing net is 250 – 350 mm.

The resistance and insulation of an electrical underfloor heating system needs to be tested **after** installation. This has to be documented by an electrician.

The positions of the coils needs to be documented carefully before they are concealed. This can be done through a scale drawing or a photograph.

The concrete must have a low viscosity and must be vibrated so that no air pockets are formed. It is important that the whole electrical heating cable is surrounded by concrete to prevent air pockets from being formed to avoid poor heat transfer and also the risk of a overheated cable.

The resistance and insulation of an electrical underfloor heating system needs to be tested **after** being embedded. This has to be documented by an electrician.

The thermostat's floor sensor shall be installed in accordance with the manufacturer's recommendations. It is important that the sensor is placed in the floor at a position representative of the whole floor surface.

When a thermostat is installed with a room sensor and a floor sensor, it is recommended that the room sensor be fitted circa 1.5 metres above the floor level on an internal wall and on a surface representative for the room. The thermostat should not, for example, be placed where it can be exposed to sunlight, close to an open fireplace or the like.

An earth-fault switch shall be installed.

D Testing

Hydronic systems:

Pressure testing, balancing and a check of the room regulation must be carried out.

Electrically conducted systems:

The resistance and insulation of an electrical underfloor heating system needs to be tested and documented before and after installation and before the construction is connected to the mains supply, to avoid the installation of damaged material.

E Start-up and operation

A wooden floor shall always be installed under the correct conditions, i.e. at a room temperature 20°C (± 2°C) and a relative humidity between 30 and 60% RH This means that the underfloor heating need not be in operation as long as the room temperature and atmospheric humidity stay within these limits.

Operating instructions from the underfloor heating supplier and the wooden floor supplier must be handed over to the user.

F Documentation

The following items have to be documented and the documentation has to be joined to the operating instructions, which shall be given to the user after the installation is completed.

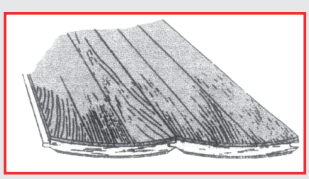
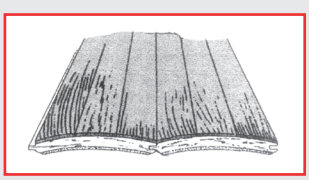
Hydronic systems:

- Heat requirement calculation
- Coil pattern and the placing of the coils
- Pressure testing
- Balancing of the separate coils and the total flow of the manifold
- Functional check of the room regulation
- Instructions for operation and maintenance with documentation relating to the components included.

Electrical systems:

- Heat requirement calculation
- Coil pattern and the placing of the coils
- Resistance and insulation testing before and after installation
- Resistance and insulation testing after the timber floor has been fitted
- Instructions for operation and maintenance with documentation relating to the components included.

TERMINOLOGY/GLOSSARY

Designation, concept	*Explanation, field of application and instructions*
Acoustic damping mat	PURPOSE/FIELD OF APPLICATION: Impact sound reducing felt which also protects the underlying vapour barrier from pressure and perforation from above. It also reduces the risk of sounds between the under side of the wooden floor and the sub floor. The mat is 2 – 25 mm thick depending on the surface materials and the density. INSTRUCTIONS: Shall be used when acoustic damping to eliminate impact sounds is a requirement. Must not be installed in several layers and shall not overlap. Shall always be placed on top of a vapour barrier. COMMENTS: Maximum thickness 3 mm with underfloor heating. It has a greater heat transfer resistance than rag felt.
Airborne sound	Sound which are transported from the acoustic source to the surroundings via the air, e.g. song, radio music etc.
Clip-installing	A system where solid floorboards are fitted with clips, see figure. 
Combination underlay *rag felt*	PURPOSE/FIELD OF APPLICATION: Combined vapour barrier and acoustic damping underlay mat. It also reduces the risk of noise between the underside of the wooden floor and the sub floor. INSTRUCTIONS: Shall be used primarily when acoustic damping is a requirement. It shall be installed according to the manufacturer's instructions. COMMENTS: Has a greater heat transfer resistance than rag felt.
Crowning/dishing	Deformation in a wooden floor, which arises as a consequence of a change in the atmospheric relative humidity. In the winter, multi layer boards develop a slightly concave shape (dishing) as a result of a low atmospheric relative humidity whereas, in the summer, a convex shape (crowning) develops instead as a result of a high atmospheric relative humidity.  Dishing (concavity)  Crowning (convexity) Solid wooden floors usually react in the same way

Damp proof membrane *Alternative name:* Air-gap-forming layer	PURPOSE/FIELD OF APPLICATION: A layer which prevents or reduces moisture transport in the vapour state and in the liquid state without hydrostatic pressure, often in the form of capillary suction. The function of the layer shall be maintained throughout the life span of the building (i.e. at least 50 years). The layer can consist of e.g. 2 – 10 mm thick air-gap-creating boards of HD polyethylene or polypropylene. INSTRUCTIONS: Note that the damp proof membrane shall always be placed beneath the underfloor heating, rag felt or acoustic damping mat. Note, that the joints shall be sealed to avoid moisture and odour. COMMENT: Must be used over a concrete floor when the RH in the concrete exceeds 95% RH. A damp proof membrane has a 5 times higher resistance to water vapour transmission than a vapour barrier. Some of damp proof membranes can be combined with mechanical ventilation according to the manufacturers' instructions.
Delimination	The loosening of the surface layer from the body of the board. Refers to the uppermost layer of multi layer wooden floors of hardwood or softwood.
Designation/concept	Explanation, field of application and instructions.
Diffusion	Transport of moisture in the vapour state takes place through diffusion (if the air is stationary). The driving force for diffusion is a difference in vapour pressure. Equalisation of moisture within and between materials takes place by diffusion. In contrast to convection and capillary suction, diffusion is a slow transport of moisture.
Diffusion barrier	See Vapour barrier
Drum/resonance sounds	The acoustic pressure levelin the same room as the source of the noise, e.g. steps from a person walking in the same room. Note: There is no standardised method for measuring drum sounds.
Equilibrium moisture content	The moisture content in wood when it is in equilibrium with the surrounding atmospheric humidity.

Floating floor

A floor that lies on top of a construction and floats without being fastened to the sub floor.

A board material or multi layer parquet is placed freely on a sub floor of concrete, particleboards etc and is joined together into a connected surface through a glueless joint or the gluing of tongues and grooves.

This term normally refers only to multi layer-constructed wooden floors. The exception is a solid wooden floor that can be installed with a clip system, which makes a floating installation possible.

Alternatively, solid wooden floors are nailed, screwed or fully glued onto a board material that is installed freely floating on a concrete floor.

In the case of multi layer parquet, adhesive-free lock constructions are also available. There are two systems; one system where boards are knocked together horizontally and one system where boards are angled upwards and then folded down so that lock ing occurs.

Floor joists
Other name:
Floor ridges, floor beams

PURPOSE/FIELD OF APPLICATION:
Standing wooden joists which constitute the supporting part of a wooden joisted floor. They are normally 45 mm thick and have a height that varies between 150 and 220 mm depending on the construction, ultimate load-bearing resistance and insulation. They are normally installed with a centre-to-centre separation of 600 mm.

INSTRUCTIONS:
Note the floor manufacturers' requirements with regard to the moisture ratio of the wood, which shall not exceed 10%.

COMMENT:
Self-supporting parquet floors and solid wooden floors with a certain thickness can be installed directly on the joists. The ultimate load-bearing resistance is dependent on the centre-to-centre distance and on the thickness of the wooden floor.

Floor temperature

The temperature during the heating season on the wooden floor surface must not exceed 27°C. This is always with the reservation that the relative humidity must never be lower than 30%.

Gaps

The gaps that arise between multi layer boards, parquet strips and floorboards when the wood dries. These normally develop during the winter when the relative humidity is low. If the floor is exposed to atmospheric humidities between 30 and 60% RF, these gaps will disappear when the RH is increased.

If the floor is permanently subjected to RH-levels higher than 60% or lower than 30%, the movements of the wood can give rise to a permanent deformation. This can mean e.g. that the surface layers come loose from the body on multi layer boards.

Height adjustable battens system	PURPOSE/FIELD OF APPLICATION: Subfloor system which is fitted on an existing raw concrete floor in order to facilitate levelling of a foundation, acoustic damping, connection to mechanical ventilation, installation of electric wiring in the space between upper floor and sub floor and the fitting of underfloor heating systems. INSTRUCTIONS: In those cases where the adjustable system makes use of wooden battens, the floor manufacturers' requirement that the moisture content of the wood shall not exceed 10% must be observed. *Multi layer parquet:* Height adjustable wooden battens shall be covered with a floor particleboard that is screwed or glued before the installaion of the multi layer boards. Self-supporting multi layer boards can be placed directly on plastic and metal battens, but not on the height adjustable wooden battens. A vapour barrier shall be placed between the floor particleboard and the wooden floor. The ultimate load-bearing resistance is dependent on the centre-to-centre distance and thickness of the wooden floor. *Solid:* Self-supporting solid wooden floors can be screwed or nailed directly onto height adjustable wooden battens. On plastic and metal battens, a particleboard or plywood board is required as an intermediate layer to permit nailing or screwing. COMMENTS: The underfloor heating should be placed in a grooved 22 mm underfloor heating particleboard or installed over a floor particleboard that is fitted onto the floors or onto specially adapted plates that are hung between the height adjustable wooden battens. The underfloor heating coils shall be equipped with a heat distributing layer. If required, the system shall be complemented with mechanical ventilation. Insulation shall be installed between the battens to avoid a high drum noise.
Impact sound	Sounds due to walking on a joisted floor, on a staircase or the like which can be heard in an adjoining room.
Moisture content (mass by volume)	The mass of vaporizable water divided by the total volume of the material. It is expressed in kg/m^3.
Moisture protection	Collective name for different types of materials and constructions that reduce or stop moisture migration.
Moisture ratio (mass by mass)	Percentage by weight of moisture calculated with respect to the oven-dry weight of the material.
Movement joint	Joint which permits movement between the surrounding constructions, e.g. between a floating floor and fixed installations such as a wall and radiator pipes.

Multi layer boards	Flooring material of boards made in a multi layer construction with a patterned surface layer of hardwood or softwood and with tongue and groove. Layered wooden floor with a thickness of 10 – 25 mm. Consists of a 2 – 6 mm thick upper surface layer of hardwood or softwood glued onto a base and with a veneer on the back.
Parquet floor	Floor covered with strip parquet, parquet squares, multi layer boards or mosaic parquet. To be called a parquet floor, a surface layer at least 2.5 mm thick is required. Note: a parquet floor can be both solide and multi layer constructed.
Rafting	Defect in a bottom or top floor which arises when the adhesion between two layers has failed, e.g. between concrete screed and bottom concrete or between foundation and surface material.
Rag felt	PURPOSE/FIELD OF APPLICATION: Lining material of 1 mm thick paperboard that protects the underlying vapour barrier from pressure and perforation from above. It also reduces the risk of noise between the underside of the wooden floor and the sub floor. INSTRUCTIONS: Shall not be used for acoustic damping. It is available with different densities depending on the requirements of the floor manufacturer. COMMENTS: It is often used before floor installaion as a levelling material if the surface does not fulfil the requirements for levelness according to AMA. Can be installed in layers or in strips. With underfloor heating, the felt should not be installed in more than three layers since this influences the heat transfer. In such cases, the surface should first be levelled with a screed compound.
Relative atmospheric humidity	The ratio of the vapour content to the saturation vapour content at the same temperature. This is designated RH and is indicated in %. The capacity of the air to absorb and contain moisture is related to the temperature of the air.
Sealing layer	A layer consisting of one or several materials with the ability to prevent water in the liquid state from penetrating into a building construction.
Secondary spaced boarding	PURPOSE/FIELD OF APPLICATION: Extra support with planed wooden planks fitted on top of or lowered between an existing wooden joist floors. Can be used as a store for underfloor heating plates and water coils.

	INSTRUCTIONS: At least 28 mm thick when installed over joists at centre-to-centre distance of 600 mm. Note the floor manufacturers' requirements with regard to the moisture ratio of the battens, which shall not exceed 10%. COMMENT: Secondary spaced boarding lowered between floor joists make high demands on accuracy with respect to flatness since the heat emission plate must be in good contact with the top floor.
Self-supporting parquet floor	Multi layer parquet floors with a thickness of at least 22 mm and certain solid parquets floors with a thickness of 20 – 26 mm.
Solid floorboards	Planed and tongued floorboards with tongue and groove either on the long sides or all round. Available in most wood types. Thicknesses 14 – 40 mm and widths 100 – 500 mm. Pine and spruce wooden floors are normally self-supporting at centre-to-centre distances of 600 mm if they are approx. 25 mm thick. This can vary depending on the quality of wood. Solid floorboards in hardwood such as beech, oak, ash, merbau etc are normally self-supporting at centre-to-centre distances of 600 mm with a thickness of at least 22 mm. Some manufacturers prescribe 20 mm. Solid floorboards in pine and spruce are normally delivered in decreasing lengths, but hardwood is available in both fixed and decreasing lengths.
Solid parquet boards	Boards consisting of composite hardwood blocks tongued and grooved on all sides.
Strip parquet	Floor covering, normally 16 – 22 mm thick, consisting of small separate parquet blocks which can be joined together into different patterns, e.g. Dutch square pattern, fishbone pattern. Usually refers to solid block parquet, but is also available as blocks with a 2- or 3-layer multi layer construction.
Structure-borne sounds	Sounds which are propagated via a building frame. Structure-borne sounds can come from walking on a joisted floor, from an elevator motor or from water pipes.
Surface layer	The uppermost layer of hardwood or softwood in multi layer wooden floors. On solid floors, the surface layer goes down to the tongue.

Tolerances	The maximum allowed divergence from the given dimensions. Examples of divergences are crookedness, curvedness, warp, joint gaps and angular deviation.
Transition joint Expansion joint	A penetrating joint in a construction which permits a movement between construction surfaces, e.g. in door openings. Cf. movement joint.
Vapour barrier Ageing permanent plastic	A layer of material, usually thin plastic sheeting, used in con struction to prevent water vapour from escaping from one area into another. PURPOSE/FIELD OF APPLICATION: Layer with the ability to prevent or reduce moisture transfer by diffusion and moisture convection during the lifespan of the building (= at least 50 years). Shall meet the requirements of the Swedish Plastic Federation's current service standard regarding a thickness of circa 0.2 mm. A parquet floor shall always be protected against moisture from the sub floor. This applies as soon as the presence of moisture is suspected or when it is known that the relative humidity (RH) in the sub floor exceeds 60%. Moisture protection in the form of a vapour barrier is com pulsory when the sub floor consists of a floor on the ground, a light concrete slab, a floor above permanently warm or humid premises, e.g. a boiler room, a wash house or the like, a warm floor (underfloor heating) or a joisted floor across a ventilated crawl space foundation. INSTRUCTIONS: Note that the vapour barrier shall always be placed under a rag felt or acoustic damping foam. Under solid wooden floors, the vapour barrier shall be used whenever the sub floor can be suspected of transporting moisture, e.g. a slab on the ground. COMMENTS: When a solid wooden floor is fastened through the vapour barrier, it maintains its function. If the relative humidity in the foundation exceeds 95%, a vapour barrier is not sufficient; a damp proof membrane must then replace this. (See Damp proof membrane). The lifespan of the vapour barrier, which is 50 years, is based on the assumption that it shall not be subjected for long periods to a temperature higher than 35°C.

Underfloor heating

Designation, concept	*Explanation, field of application and instructions*
Comfort heating	A type of underfloor heating system, which has only a comfort function and does not have the principal task of heating the room, e.g. in a bathroom or hall where tiles or a similar flooring is otherwise felt to be cold to walk on. These systems are often combined with radiators, which already completely or partially fulfil the heating requirement of the room.
Covering	This refers to rugs, furniture with plinth etc., which prevents ventilation and anything else, which can be considered to cover the floor surface which is heated by underfloor heating.
Design outdoor temperature	Calculated outdoor temperature for which the temperature of the room air decreases by a certain value in the event of an extreme outdoor temperature that occurs not more than once in n years. In rooms where persons are staying more than temporarily, the temperature is allowed to decrease by not more than 3°C and n is set to 20 years.
Edge zones/peripheral areas	Underfloor heating zone dimensioned to give a higher heat output along window sections or walls where there is a cold.
Floor sensor	A sensor which is placed in the floor, and which measures the local floor temperature.
Grooved underfloor heating board	Grooved 22 mm floor particleboard for wooden joisted floors with a maximum beam distance of 600 mm. Heat emission plates are placed in the grooves (see heat emission plate) and the underfloor heating pipe is then pressed down into the heat emission plate. Grooved board systems are also available as insulating boards in polystyrene such as EPS and XPS. There are also low building boards in wood or EPS to give the lowest building height. Common to all these polystyrene systems is that they shall all be installed over a supporting sub floor. Heat emission plates or heat distributing foil is placed in the grooves and the underfloor heating pipe/cable is then pressed down into the grooves. In addition to the above, there are also grooved fibreboards, which combine acoustic damping with hydronic underfloor heating.
Heat capacity	A unit, which indicates the ability of a material to store energy (heat). The unit is measured in joule per kilogram Kelvin (J/kg*K). This expresses how much energy (heat) a material has the ability to absorb in relation to its weight per unit temperature increase.
Heat distributing layer	The material, which is intended for the transfer and distribution of the heat from pipes or cables to the floor. The layer can consist of concrete, plastic filler or plates/foil of metal.

Heat emission plate (cassette)	Metal material used to transport and distribute the heat from pipes to floor. The plates are used in the different grooved board solutions in the underfloor heating systems. Another application is in so-called open panel installation. (See Secondary spaced boarding.) Heat emission cassette, with two or three grooves, is installed between the floor battens. The systems presuppose a standard wooden joisted floor with a centre-to-centre lath distance of 600 mm. The plate is nailed on the top side of the floor battens so that it is in contact with the upper floor. INSTRUCTIONS: Self-supporting multi layer boards that are placed over underfloor heating plates with an over-strain (convex shape) shall be nailed or screwed into the wooden joisted floor, in accordance with the floor manufacturer's instructions.
Heating foil	Laminated plastic foil furnished with an electrically conducting layer.
Heating mat	Net carpet with a thin series-resistive cable fastened to the net with a given centre-to-centre distance.
Heat requirement/ Power requirement	The heat requirement is calculated according to the heat losses through floor, walls, ceiling and ventilation. The heat requirement is usually expressed as the total power in watts for the room or as watt/m^2. For an underfloor heating system, these means that this power must be completely, or sometimes partially, provided. The dimensioning heat requirement is often referred to. (See Dimensioning external temperature.) COMMENTS: It is the duty of the orderer/user to supply a documented heat requirement calculation to the electrician who installs the underfloor heating system. The heat requirement calculation shall always exist as a basis for the calculation of flows and temperatures etc.
Heat storage	A good heat storage material shall have a high specific heat (i.e. a high ability to absorb heat per unit weight per unit temperature increase) and a high density, so that the material shall be able to absorb as much heat as possible per unit volume. The material must not be a good heat insulator, i.e. it must not have a high heat transfer resistance. A good heat storage material is concrete which has a high specific heat, a high density and low heat transfer resistance. Dry concrete with a density of 2.0 kg/dm^3 can store energy as follows:

	Concrete with a thickness of 1 cm stores ca. 5 Wh/m^2 per °C temperature increase Concrete with a thickness of 10 cm stores ca. 50 Wh/m^2 per °C temperature increase Concrete with a thickness of 20 cm stores ca. 100 Wh/m^2 per °C temperature increase COMMENTS: The ability of the flooring to "store" heat is insignificant since the flooring seldom has a thickness, which exceeds 10 – 20 mm.
Low-temperature system	Heating system with low system temperatures, with the possibility of providing a connection with alternative heat sources.
Manifold	A unit to which several underfloor heating coils consisting of an inflow tube and return pipe are connected. The manifold is usually designed so that it is possible to balance, shut off and regulate the separate coils individually.
Outdoor sensor	A sensor which has been placed outdoors, e.g. on an external wall. This sensor measures the outdoor temperature and feedback from this measurement is used to control the influx temperature. This applies only to hydronic systems.
Pipe clip strips	Holder for the underfloor heating pipes when they are cast in concrete. The beam is fastened to the foundation (cellular plastic or concrete) and gives a correct centre-to-centre distance between the pipes.
Power	The "strength" with which the heating system supplies heat. Unit W (watt).
Power/square metre	The power divided by the heated area of the heating floor (W/m^2).
Return pipes	The return circuit of the heating water to the heat source from the underfloor heating manifold.
Return temperature	The temperature of the water in the return pipe from the underfloor heating manifold to the heat source.
Room sensor	A sensor which is placed in the room, e.g. on the wall. In general, this measures the air temperature (locally, where the sensor is fitted).
Room thermostat with floor sensor	A thermostat placed in the room to control the underfloor heating system. The air in the room is maintained at the desired temperature. The floor sensor can be used as a local protection, to prevent the floor temperature from becoming too high.

Security thermostat	Separate thermostat for a hydronic system, which prevents hot water from entering the coils, for underfloor heating normally set at 50°C. It is usually fitted in connection with the manifold, but it can also be fitted in relation to the boiler/heat source.
Self-regulation heating cable	An electrical cable which adapts its power according to the surrounding temperature. If the surface is cooled, the power increases and, if the surface is covered, the power decreases.
Sensor	A sensor which measures the conditions in the space/object where it is placed. Its output signal is received by regulating equipment. In an underfloor heating context, a temperature sensor is usually used.
Series-resistive heating cable (constant power)	The most common type of heating cable. The cable emits a constant power regardless of temperature, i.e. the power of the cable is determined by the cable's specific resistance and length and applied voltage.
Shunt	Device for mixing warm water from a furnace etc with colder water from the return pipe so that the water in the supply pipe has the desired temperature.
Supply pipes, flow pipes	The inflow pipe leading the heating water from the heat source to the underfloor heating manifold.
Supply temperature	The temperature of the heating water in the supply pipe to the underfloor heating manifold.
Tying	Method of installing underfloor heating pipes in concrete. The pipes are "bound" into the reinforcing mesht. Both plastic strips and binding wire can be used.
Thermal transmittance, U-value	The ability of a single- or multi-layer construction to transmit heat. A high number means a low resistance and gives a high heat flow through the layer/layers. Floors with high heat transfer coefficients are tiles and plastic floor-coverings. Floors with relatively low heat transfer coefficients are wooden floors and particleboards.
Thermostat	Temperature regulating device, the operating temperature of which can be either fixed or adjustable. In normal operation, it keeps the air temperature of the room within certain limits by regulating the current to an electrical underfloor heating system or by steering an actuator, which regulates the water flow to a hydronic underfloor heating system.
Thermostat with floor sensor	A thermostat, which regulates the underfloor heating system so that it heats the floor to a preset/desired level.

Appendix

House AMA DESCRIPTIVE TEXTS IN SWEDISH BUILDING REGULATIONS

KEB.2341 Layer of plywood boards over a sub floor of concrete, light concrete or the like as a floating foundation suitable for nailing parquet strips.

MATERIAL AND GOODS REQUIREMENTS
The boards shall be at least 7 mm thick; in sports centres or the like at least 9 mm thick.

INSTRUCTIONS
The boards shall be installed in two layers. Each layer shall be installed in a bond pattern with a gap of at least 6 mm and not more than 9 mm between the boards. The upper board layer shall be installed perpendicular to the lower layer. The joints in the two layers shall be displaced by at least 150 mm.

The boards in the upper layer shall be fastened to the lower layer with 3-6 screws per square metre. The screws shall be countersunk. The screw length shall be adapted to the total thickness of the boards and shall be such that the screw tip does not penetrate the board.

KEB.2342. A layer of plywood boards over a sub floor of concrete, light concrete or the like as a floating foundation for gluing parquet strips.

MATERIALS AND ARTICLE INSTRUCTIONS
The boards shall be at least 12 mm thick and shall be grooved along all edges.

INSTRUCTIONS
The boards shall be installed with displaced joints and shall be glued in the joints with PVAc or an equivalent adhesive. The amount of adhesive shall be such that the whole joint is filled and small excess is pressed out from the joint during the gluing operation. The excess adhesive shall be removed immediately. During the setting period, pressure shall be applied. The floor must not be used while the adhesive is setting.

KEJ.234 Layer of particle boards over a sub floor of concrete, light concrete or the like. The particleboards shall be at least class 2 according to the Swedish Standard SS 23 48 01.

INSTRUCTIONS
The sub floor shall be covered with a moisture protection of plastic film. The boards must not however be installed over a sub floor covered with plastic film if the relative humidity (RH) in the sub floor exceeds 95%.

The boards shall be installed with displaced joints and shall be glued in the joints with PVAc or an equivalent adhesive. The amount of adhesive shall be such that the whole joint is filled and a small surplus is pressed out from the joint during the gluing operation. The excess adhesive shall be removed immediately after gluing. During the setting period, pressure shall be applied. The floor must not be walked on while the glue is setting.

Wooden floors over underfloor heating

is published by the Swedish Flooring Trade Association, GBR, and is the result of a co-operation between GBR, the country's leading wooden floor suppliers and underfloor heating suppliers. This guide to good practice provides basic information, trade guidelines and terminology and is intended for use in the planning, construction, design and operation of underfloor heating and wooden floor installations.

During recent years, interest in wooden floors has continuously increased. At the same time, underfloor heating systems have become increasingly common as a primary heat source in public environments and in houses. At the same rate, the number of complaints relating to wooden floors over underfloor heating has increased, as a result of e.g. incorrect handling, inadequate conditions, a lack of joint trade recommendations and a general ignorance about foundation constructions and the installing of wooden floors in combination with underfloor heating.

Wooden floors over underfloor heating is written for everyone who is considering wooden floors, whether solid wooden or multi layer parquet, over an electrical or hydronic underfloor heating system. This guide to good practice can also be used as a training material and copies can be ordered through the contributing companies.

The Swedish Flooring Trade Association, GBR,
is engaged in information, research and technical/legal consultations. The organization includes contractors, floor specialist retailers and suppliers.

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