MAKING MODERN LIVING POSSIBLE

Introduction to Hydronic Floor Heating

DANFOSS HEATING SOLUTIONS

Handbook

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Introduction

In recent years, underfloor heating has become increasingly popular. This is due to the fact that underfloor heating provides a range of opportunities not offered by traditional heating methods both in residential and commercial buildings.
However, underfloor heating also offers some challenges and in order to make the very most of the opportunities it is important to choose the right solutions with regard to floor construction and regulation method.

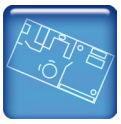
Danfoss offers a versatile range of products for complete floor heating systems which are all based on two main principles:

- Danfoss floor heating solutions are optimized for easy, fast and safe, installation by the installer
- Danfoss floor heating solutions ensure that the end-users experience optimal thermal comfort at minimal energy consumption

Why choose floor heating?

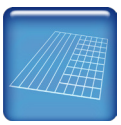
In most countries, floor heating is the preferred heating method in new buildings. This is particularly the case in residential properties, but in office buildings and other commercial properties it is also increasingly popular. Floor heating gives the end-user a number of benefits:

No '"ugly'" radiators which require cleaning.



Furniture can be placed as required without having to take radiators into consideration.

Floor heating provides comfortable heating as your feet are kept warm while your head is kept slightly cooler. Most people find this difference in temperature between feet and head most comfortable.



There is currently a tendency to prefer wood and tiled floors over carpeting. It is exactly for these '"cold'" materials that floor heating can provide extra comfort.

As floor heating supplies heat to the entire room, the differences in temperature that occur between a radiator and the furthest corner of the room are avoided.

Currently, people are focusing much more on their indoor climate. Increasing numbers are plagued by asthma and allergic problems and it is therefore important that thorough cleaning of the home is made possible. Floor heating makes cleaning much easier. In addition – due to the large heating surface – floor heating means that less air is mixed and thereby less dust occurs in the room.

Everyone is familiar with the problem of water on the bathroom floor. With floor heating, water evaporates quickly and the floor quickly becomes dry and warm again.

With floor heating the room temperature can be lowered 1-2 °C which means energy savings of 6-12 %.

Where can floor heating be used?

As long as the floor heating system is properly designed and installed with regard to floor construction, cover, materials, etc., there are practically no limits to where it can be used.

- Floor heating can be used for all floor finishes, tiled floors, wood (solid/parquet), linoleum and carpeting (although the output temperature must be calculated accordingly)
- Floor heating can be used in all new buildings
- For renovation of existing buildings the installation height may be a limiting factor, but for this type of application products like the Danfoss SpeedUp™ and SpeedUp Eco™ systems offering very low built-in height are available
- For renovation of single rooms, floor heating connected to the existing heating system and equipped with a self-acting regulating valve, can be a good and an economical solution
- For installation of floor heating in the entire property, wireless controls like Danfoss CF2 control system is a great advantage, because no electrical cables need to be wired
- Floor heating can be used with all heating supply systems. However, the output temperature must be adjusted so that the floor surface temperature never exceeds the recommended value (e.g. recommended by the wooden floor supplier).

Energy consumption

The heat consumption of floor heating has been a much-discussed issue for many years. There have been many claims about rising heating bills for floor heating instead of more traditional radiator systems.
When floor heating was originally introduced, house constructions were not changed and floor heating was simply installed by running floor heating pipes in floors, which otherwise were constructed as usual.
As the floor heating pipes are embedded in the floor, automatically, there is a greater heat loss downwards and thereby a negative effect on the heating bill.

Today, things have changed – the floor construction is insulated far better than before and now special requirements are in place for the installation of floor heating.
This means heat loss from the building is now typically equally good for houses heated with floor heating systems as for houses heated with more traditional heating systems.

But other factors affect energy consumption when comparing floor heating to other heating options namely user behaviour and personal comfort. Most people find it most comfortable to keep their head a couple of degrees cooler than their feet and the room temperature when using floor heating can therefore advantageously be reduced by 1-2 °C in comparison to traditional radiators, which means energy savings of 6-12 %.

Comfort and user behaviour

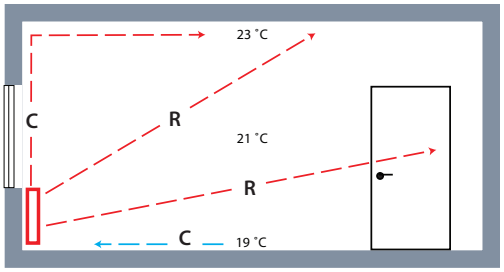
In contrast, most people feel comfortable with warm feet – and the floor temperature can then be so high that the room temperature becomes uncomfortable, e.g. in bathrooms with tiled floors.
The above examples of user behaviour pull in different directions when it comes to energy consumption and show that it can be difficult to provide an unambiguous answer to what floor heating means for energy consumption as this will depend very much on the individual consumer.
However, it can be concluded that compared to other heating systems floor heating - if used correctly - will save energy and at the same time provide better comfort for the end-user.

Temperatures in the room

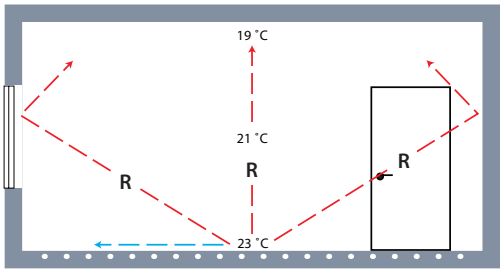
The temperature experienced in a room is the result of two different factors, air temperature and ambient radiation, i.e. from the heated elements in the room. It can be an advantage in many ways that heat radiation constitutes a relatively high part of the "overall" temperature or the operative temperature as it is also called. If a large part of the operative temperature is made up of the air temperature, it means that there will be a high convection or mixing of air in the room.

If there is high mixing, air is whirled around which can be bothersome as well as mean a higher dust content in the air and thereby a poorer air quality. The way convection/ radiation occurs with radiators and floor heating respectively can be seen below.

As can be seen, with radiator systems the air temperature or convection makes up approx. 70 % of the operative temperature. This is also logical if you think about how a radiator has quite a small surface from which to transfer heat to the whole room. Conversely, floor heating supplies heat through a very large surface evenly distributed in the room which means that the ratio is just the reverse with 70 % of the operative temperature being added by radiation.



Radiators: 70 % convection/30 % radiation



Floor heating: 30 % convection/70 % radiation

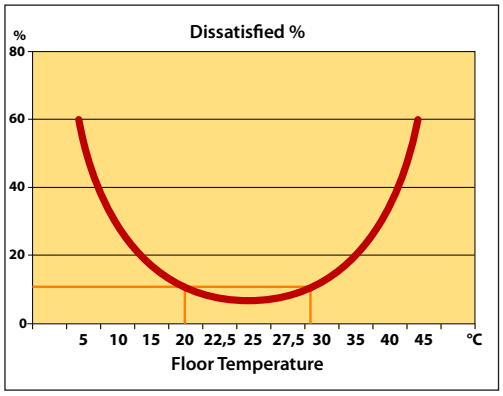
Optimum floor temperature

People differ in their perception of what a comfortable temperature is. It is therefore not possible to define an optimum floor temperature to suit everyone. Recommendations for floor surface temperatures can only be provided to ensure that a minimum number of people are 'dissatisfied'.

The figure illustrates that at any given temperature there will always be approx. 10% who will not think that the temperature is comfortable.

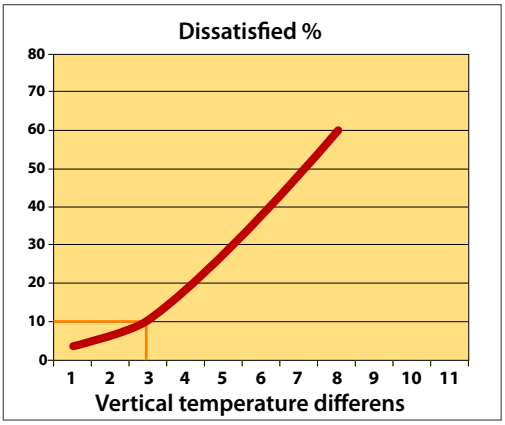
Typically, it is recommended that floor heating temperatures should fall within the following ranges: living areas 19-24 °C and bathrooms 24-29 °C.

A minimum number of dissatisfied people will be found in these ranges.



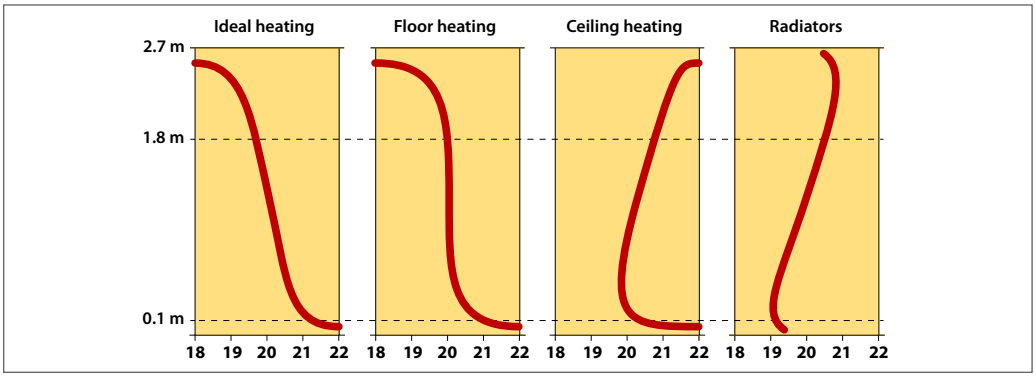
Temperature distribution in the room

In practice, it is not possible to maintain the same temperature everywhere in a room. As warm air rises, there will always be a flow of warm air from the heat source towards the ceiling.
This temperature difference should not be too large. For vertical temperature differences, it is recommended that a difference of approx. 2 °C between floor and head height should be maintained. This is because most people want to have warm feet while keeping 'a cool head'.
But the difference in temperature should not exceed approx. 3 °C as the body will become 'confused' and comfort is reduced.



The diagram below illustrates how the temperature is distributed vertically with different types of heating. As can be seen, the vertical temperature distribution for floor heating is almost identical to the ideal distribution.

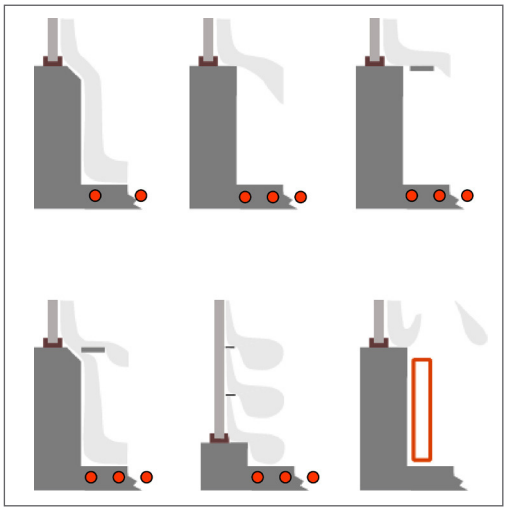
This means that the average temperature for floor heating can often be reduced without compromising on comfort and this means that energy consumption falls.



Heat loss

Sudden heat loss may occur - especially in older buildings or in commercial buildings with large/ high windows.

Heat losses occur when insulation in part of a building - e.g. a window - is not efficient and a large difference in temperature arises between the areas near the ceiling of the room and the floor surface. This temperature difference means that the air is cooled significantly near the building's ceiling and - as cold air is heavier than warm air - the air 'falls' down towards the floor at a relatively high speed.
This can be a nuisance and create draught problems. To counteract this problem, the heat source is typically placed in the location where heat loss is expected so that an opposite, upward air flow is created to offset it.



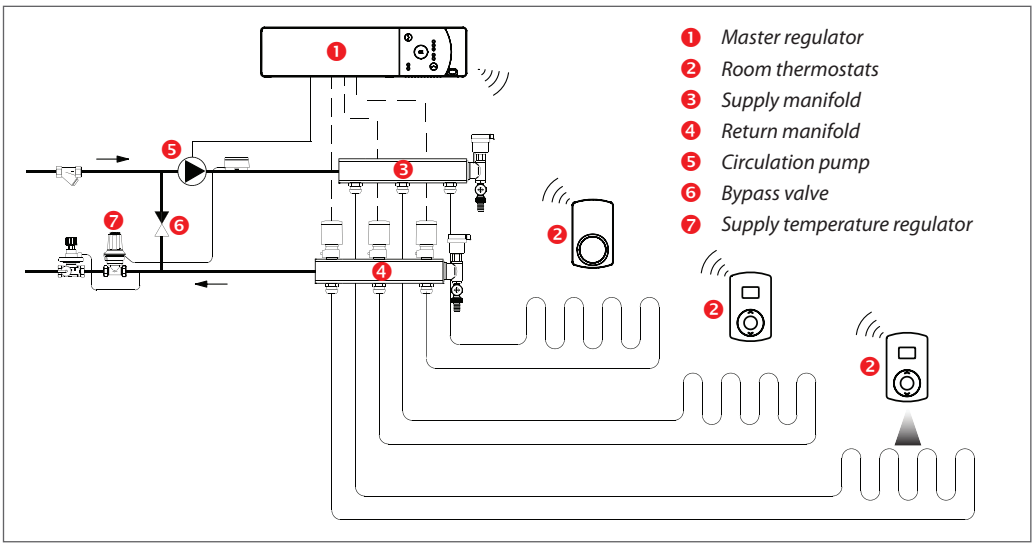
With floor heating this option is not possible as the heat output covers the whole floor. However, several options exist to alleviate any such problems:

- Low energy windows with more efficient insulation can be used.
- The floor heating pipes can be laid at smaller intervals to increase the effect where required (please note that any stipulated max. surface temperature must still not be exceeded).
- It can be ensured that the floor heating supply pipe is placed in the problem area.
- Window constructions can be optimised - e.g. a projection to break the cold air flow.
- Supplementary heating can be installed in the form of convectors.

Floor heating system dimensioning

Floor heating is a low-temperature heating system and there will usually be a need to mix the temperature from the primary heat source to typically 30-40 °C via a mixing circuit like Danfoss Compact Mixing Shunt.

The main products for controlling a floor heating system on the secondary side (low temperature side) will typically be as illustrated below.



For a full dimensioning of a floor heating system, a calculation programme will be required as e.g. the calculation of supply temperature is complex and requires detailed knowledge of heat transmission in the floor's different materials, etc.

In order to help the installer dimension, install and commission the floor heating system correctly Danfoss can - based on relevant input from the customer - provide a number of services for the complete floor heating system:

- Drawings and pipe lay out
- Product training
- Dimensioning and parts list
- Ekstensive technical documentation
- Technical and after-sales support
- Direct on-site support

Danfoss - behind you all the way

For all heat sources

The floor heating system is a low temperature system with a typical supply temperature of 30-40 °C. This means floor heating systems can be supplied from alternative heat sources such as solar heat and heat pumps. The efficiency of a heat pump varies very much depending on what supply temperature is required. If the water temperature supplied by the heat pump can be reduced the efficiency of the heat pump increases significantly, as per table.

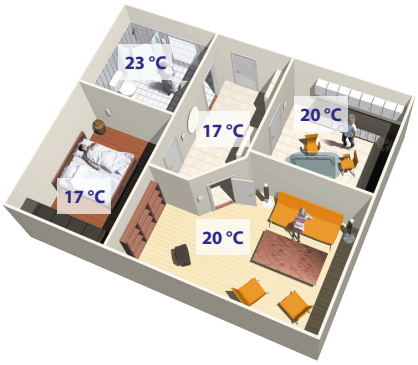
As an example if a floor heating system is designed for a supply temperature of 35 °C and a traditional heating system requires e.g. 55 °C. Then the coefficient of performance (COP) for the heat pump will - in accordance with the table - be respectively 5.0 and 3.2. Or in other words the efficiency of the heat pump will be 56 % better when used together with a floor heating system compared to use with a traditional heating system.
Therefore, the Danfoss floor heating systems combined with a Danfoss heat pump will make up the optimal heating system with regard to energy savings considering both the heat source and the floor heating system.

Supply temperature to the housebuilding	*Brine temperatur from the collector*			
	°C	*-5*	*0*	*5*
	35	*3.9*	*4.5*	*5.0*
	40	*3.5*	*4.0*	*4.5*
	45	*3.1*	*3.5*	*4.0*
	50	*2.8*	*3.2*	*3.6*
	55	*2.5*	*2.8*	*3.2*

Individual room temperature regulation

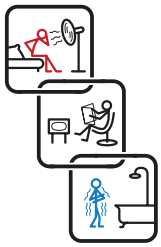
The temperatures in the rooms in which we live and work play an important role in our wellbeing. It should not be too hot or too cold, and the temperature must be adjusted in relation to what we are wearing and what we are doing at the time.
For example, office workers typically wear lighter clothes and have a lower body temperature than personnel packing products in the warehouse. The room temperature should therefore be higher in the areas where office workers carry out their tasks.

Typical room temperatures in a residential building:

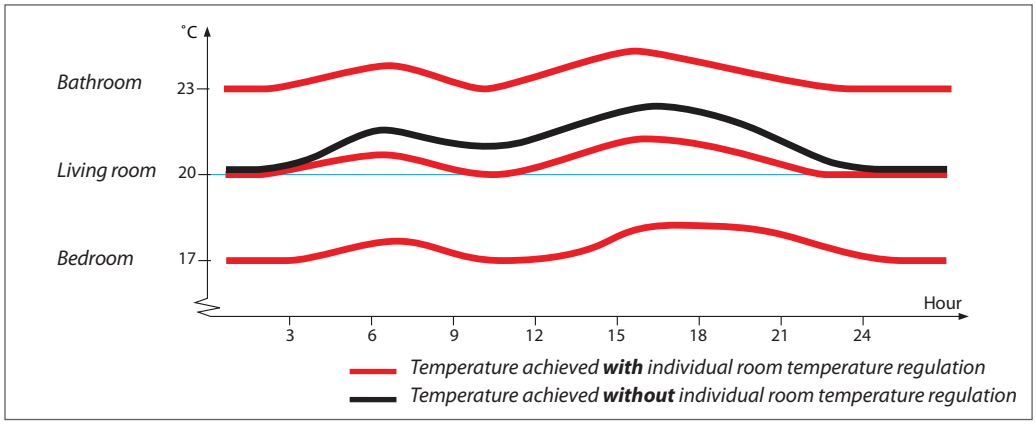


Activities and clothing vary from room to room, which is why the temperature should be adjusted accordingly.

The ultimate goal of temperature regulation is to ensure maximum comfort combined with minimal energy consumption.
This means that the heating system must constantly ensure that the temperature is always suitable in the different rooms, without noticeable variations.

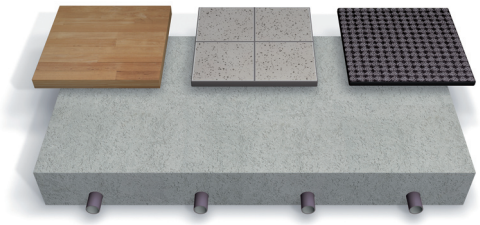


There are a range of factors that must be taken into account, such as the activities and clothing of the people in the room, heat loss and heat gain through windows, lights, computers and other sources of heat.
As a minimum, the temperature must be regulated individually in the separate rooms or zones.
Independent tests and simulations have been carried out with the purpose of establishing the importance of regulating temperature in individual rooms for people's comfort and for energy consumption. The results vary, depending on the house/apartment in question, its construction and user patterns, as well as on the test method used. However, the results are all clear on one point – namely, they generally support the importance of individual room temperature regulation for both comfort and energy consumption.
It has been shown that energy savings of ~ 25% can be gained without compromising comfort.

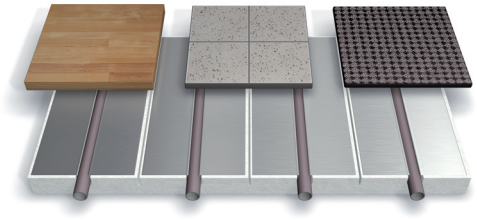


Floor construction and system performance

In order to achieve best possible comfort for the end-user, main purpose for the heating system is to provide exactly the right amount of heat at the right time and in the specific needed room. In order to do so the floor heating controls must be able to regulate each room individually.
However, this is not enough, the heat emitter - in this case the floor - must also be taken into consideration. Typically, floor heating systems have been based on pipes embedded in concrete, thus making the amount of energy stored in the heating system very large.



Typical heavy floor with pipes embedded in concrete



Light floor (Danfoss SpeedUp™)

This means when a room has reached the desired temperature and the room thermostat shuts down, the supply of warm water to the room, the floor will still continue supplying heat until the floor surface temperature reaches the room temperature.
This is a process which can take several hours during which the room temperature will continue to increase. In order to overcome this problem it is necessary that the heat emitter reacts quickly to sudden temperature changes in the room.
As opposed to traditional concrete floors which are "heavy" in terms of reaction time "light" floors constructed by insulation material and heat distribution plates - as Danfoss SpeedUp™ and SpeedUp Eco™ - are much quicker and allows for a more precise control of the temperatures in the room.

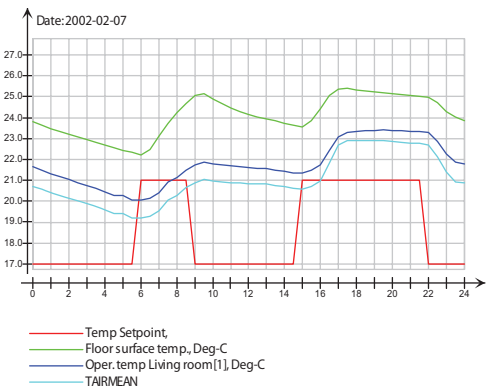
Example

In this example a traditional "heavy" floor is compared with the "light" Danfoss SpeedUp™ floor, both installed in a typical one-family house.

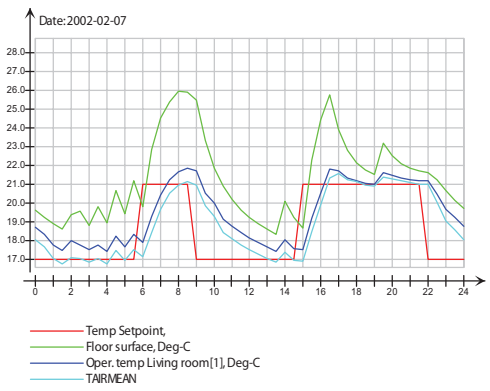
The graphs show the development in actual temperatures over a period of 24 hours including two set-back periods where the set-point temperature is changed from 21 °C to 17 °C.

The performance of each system is illustrated by how well the actual temperature (———) follows the desired set-point temperature (———). When analyzing the graphs it is evident that the light floor is better capable of following the desired set-point temperature than the heavy floor which is too slow for a set-back period to have any effect. Main reason for the difference is also clearly illustrated by the graph showing floor temperature (———) which for the light floor increase and decrease very quickly compared to the one of the heavy floor.

"Heavy" floor construction



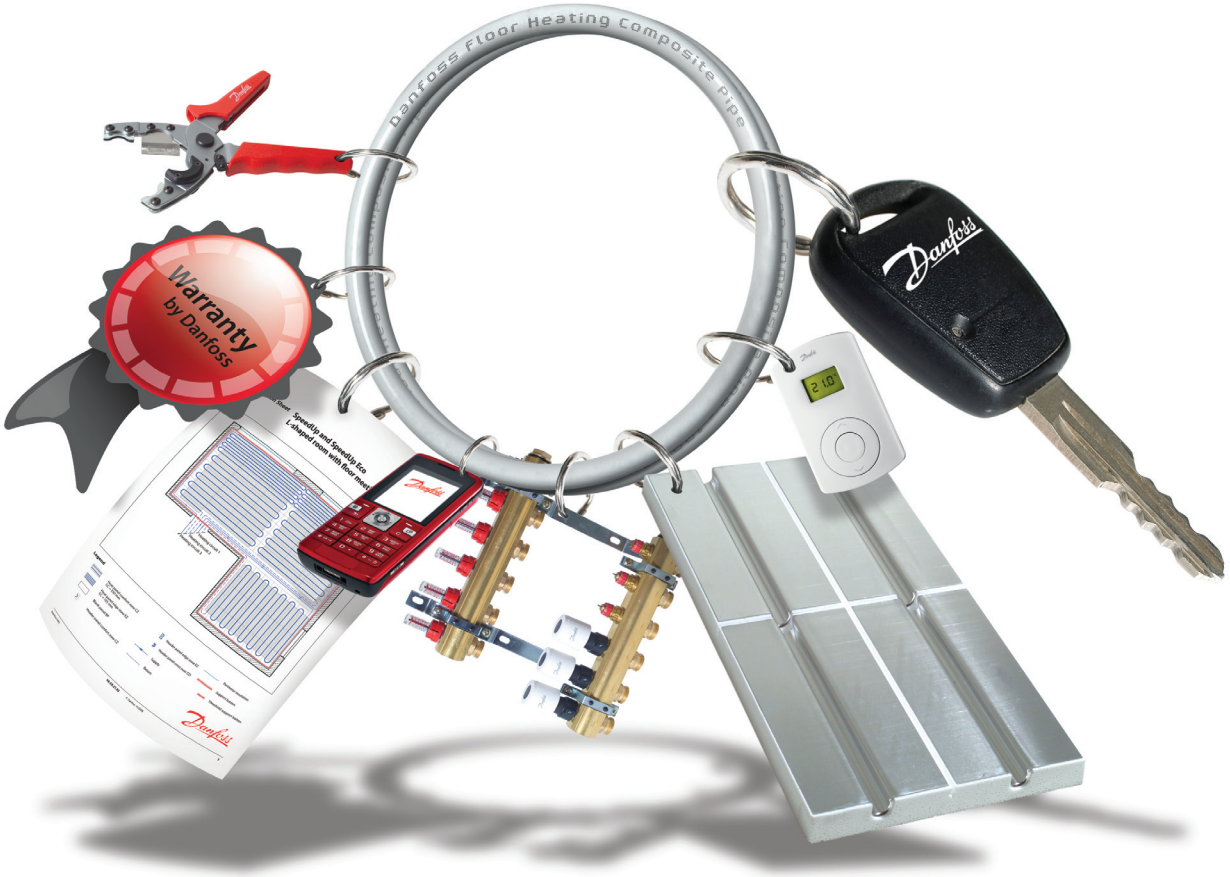
Danfoss SpeedUp™ "light" floor construction



The simulations are worked out in the simulation programme, IDA Indoor Climate and Energy 3.0.

Summary

The Danfoss floor heating systems ensure optimum comfort at all times.
The precise regulation of the CF2 wireless controls together with the rapid response of the SpeedUp floor panels provides you with the desired temperature in minutes; not hours, thus providing you with energy savings and reduced costs.



Your Key to Optimum Floor Heating

Floor heating is much more than pipes! The optimum floor heating solution provides accurate temperature control, instant heat, comfort and energy efficiency. Danfoss will provide you with optimum floor heating solutions.

The Danfoss solutions rank among the best and the most advanced in the world; combining years of experience with development and technical know-how. We provide floor heating solutions which are both quickly and easily installed for you.

Our wide range of products and our technical expertise make Danfoss your one-stop provider, saving you both time and worries. And the more time you save on installation and servicing, the more time you have to optimise your business opportunities.