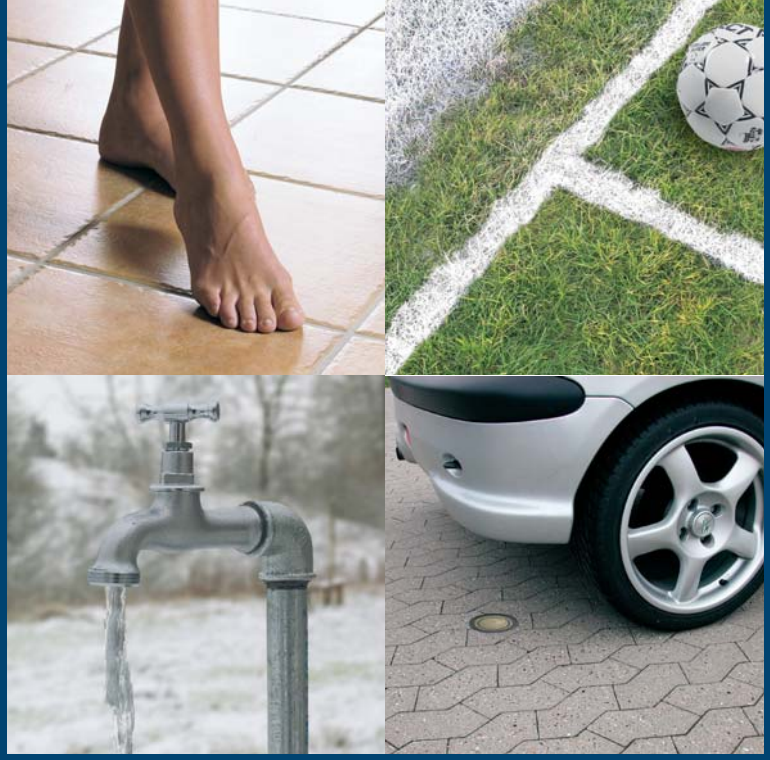
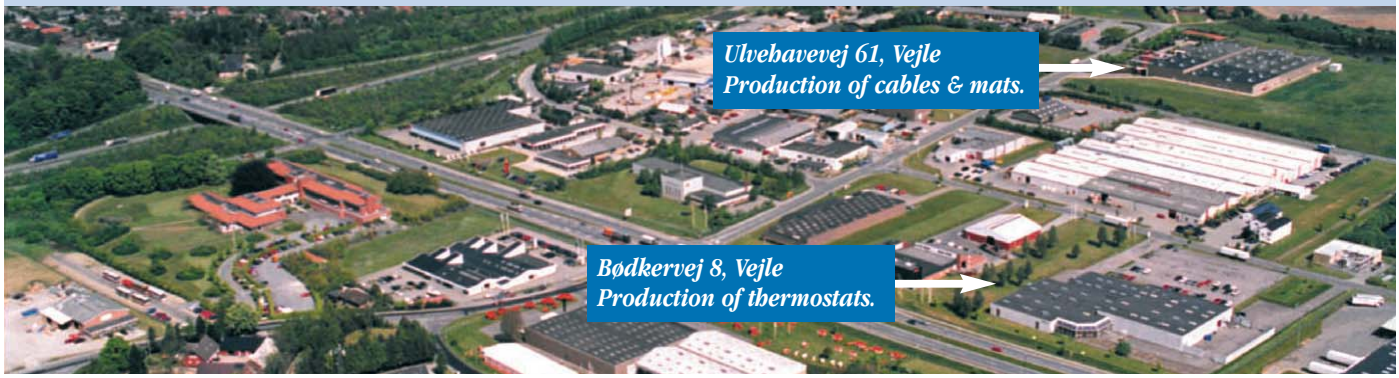


Complete DEVI Systems

www.devi.com

intelligent heating



DEVI™

DEVI is Europe's largest supplier of electrical floor heating. Our business philosophy is to develop and market electrical heating solutions that clearly stand out on account of:

- Increased comfort in everyday life
- Greater reliability
- Better design
- Improved operating costs

Complete systems

DEVI is the only company in the industry that develops, produces and markets complete systems containing both heating cables and thermostats. Consequently, there is complete concord between the single components that make up our heating systems, which means high performance, optimum reliability and usability and a correspondingly low energy consumption.

Complete solutions

DEVI manufactures a wide range of tried and tested heating cable solutions – everything from thin heating mat systems mainly intended for renovation purposes to complete heating systems for room heating in private dwellings as well as offices and industrial buildings.

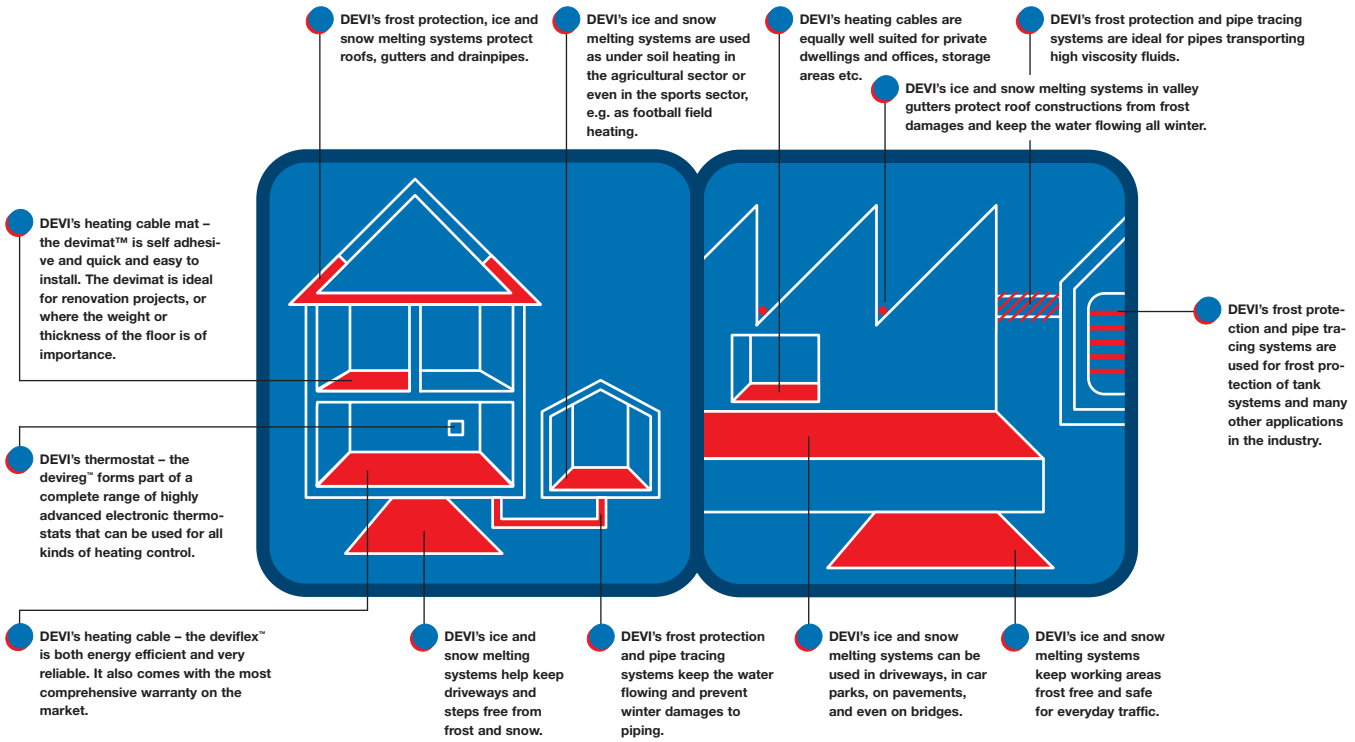
DEVI also supplies ice and snow melting solutions. Our cables and thermostats keep traffic areas, loading ramps and roof constructions safe in cold areas throughout the world.

We provide anti-frost systems for pipes and roof gutters and we heat the soil in greenhouses or even under football fields.

Environment and quality

At DEVI we set high standards for our products, all of which are designed and tested according to the most stringent norms. Our manufacturing facilities in Vejle, Denmark are certified according to ISO 9001. We take pride in being environmentally considerate:

- in the production process by focusing on minimizing both energy consumption and emissions to the surroundings;
- in the use of modern materials by avoiding e.g. led and PVC;
- in the daily use of our products, where our thermostats set today's standards for minimium energy consumption at maximum comfort levels.

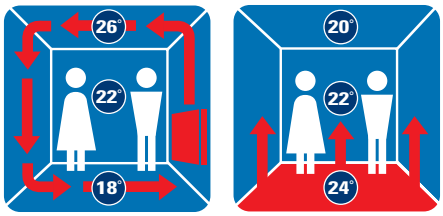


1.1 General information

DEVI's floor heating systems consist of deviflex™ heating cables or devimat™ heating mats, devireg™ temperature regulation thermostats, and installation accessories. The system can be connected into the network using the devicom™ network solutions.

Optimal comfort
All heat moves upwards! This simple fact explains why a floor heating system provides more comfortable heat than the alternative radiator system. A radiator system throws the heat up at head height, which then travels further up to the ceiling only to travel downwards and return as a cold draft around ones feet.

DEVI's floor heating system, on the other hand, provides pleasant heat for ones feet, body and head. As it produces only a very gentle upward air movement, the amount of travelling dust particles is reduced considerably, obviously making the system a great asset to people suffering from allergies or asthma.



Minimal energy consumption
Thanks to a heat distribution from the floor and a precise temperature control system with a devireg™ thermostat, the average room temperature can be reduced by 1-2°C compared with traditional radiator heating without influencing the thermal comfort level. This enables a reduction of the energy loss by up to 10-20%, which is both economical and environmentally beneficial.

A flexible system
DEVI's floor heating system ensures a comfortable room temperature, be it at home, at the office, in a workshop, sports hall or virtually anywhere where comfortable heat is required. Equally important is the fact that DEVI's floor heating system may be installed in all types of floor whether they are new concrete floors, wooden floors or renovated floors.

An invisible heat source
DEVI's floor heating system is invisible. As the system is hidden under the floor, it gives excitingly new possibilities for furnishing and interior design and the problem of space-consuming and unattractive radiators no longer has to be considered.

High durability, no maintenance
DEVI's floor heating system has a long life. Practically speaking one can count on DEVI's heating cables and mats to last as long as the house in which they are installed – and no maintenance is required!

DEVI's heating cables and mats come with a 10-year guarantee
The deviflex™ and the devimat™ are provided with a 10-year guarantee. The devireg™ thermostats have a life expectancy reflecting their stage of technical development at the time of installation. The devireg™ thermostats are provided with a 2-year guarantee.

1.2 Direct heating in concrete floors

Direct heating systems require an installed output of up to 150 W/m² and the heating cables are placed near the floor surface. Normally, heating cables or mats are placed in the lower part of a concrete layer with a max. thickness of 5 cm.

The direct heating system may be installed either as a total heating system or as a supplementary heating system. As a total heating system the DEVI system is the only heating system in a room. As a supplementary heating system the DEVI system supplements another heating system in a room, e.g. electrical radiators.

The total heating system is designed to cover the total heat loss and provide full heating while the supplementary heating system is designed to provide a warm and comfortable floor.

Installed output
The installed output shows how many watts per m² (W/m²) have to be installed in order to cover the heat loss and provide the necessary heating. The heat loss mainly depends on the climate conditions and the insulation in the building. We will assume that information about the heat loss is available.

When the total heating output for a room is to be determined, the available area (m²) has to be estimated. This means that the area covered by cupboards, bathtubs, lavatories, etc. has to be deducted from the total area of the room. Therefore, the required installed output will be proportionally higher on the usable floor space.

In order to ensure a quickly responding heating system, the total calculated output has to be increased by approx. 30%. The result of this calculation will reveal the required output for the heating element – cable or mat.

Normally, the calculated output for a new and well insulated building would be 40-60 W/m² and up to 150 W/m² in the bathrooms. If the calculated installed output is higher than 150 W/m², we recommend that additional heating systems be considered.

In houses with large glass and door areas we recommend the use of rim zone heating. The installed output in a rim zone area is approx. 200 W/m². For further information about rim zone heating, please refer to the paragraph “Accumulating heating”.

Product choice
When DEVI’s heating system is installed as a direct heating system, the deviflex™ cables with a maximum output of 18 W/m should be used. Besides, the devifast™ fitting bands will ensure a quick and easy installation.

Alternatively, the devimat™ (a preprepared cable mat) with a maximum output of 150 W/m² may be used.

When the total required output has been calculated, the cable with the nearest and higher output should be chosen.

To exploit the optimal comfort and economy of the system thermostats with simple or intelligent timers should be used – the devireg™ 540 or the devireg™ 550.

Installation
Heating cables or mats should be installed approx. 3-5 cm below floor surface and with a C-C distance of 5-15 cm.

For the installation of deviflex™ heating cables we recommend the use of devifast™ fitting bands. Alternatively, the cables may be attached to concrete armouring.

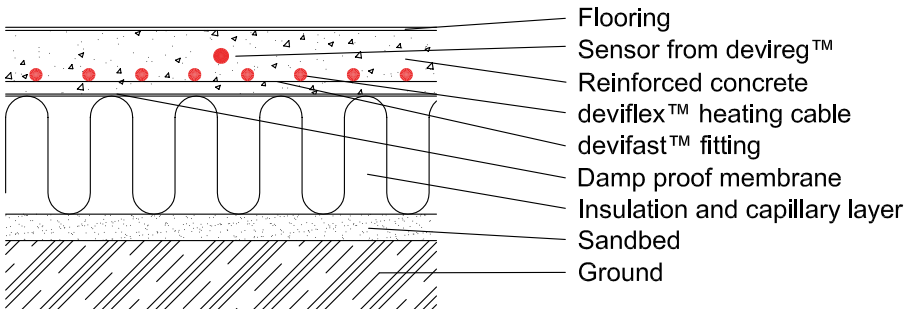
It is important that the floor construction is well insulated so the downward heat loss is kept to a minimum.

Another important element is the vertical rim zone insulation. This insulation must be efficient in order to prevent heat from being transported to the walls or the adjoining rooms. Besides, it should be able to respond to the horizontal expansibility of the floor construction.

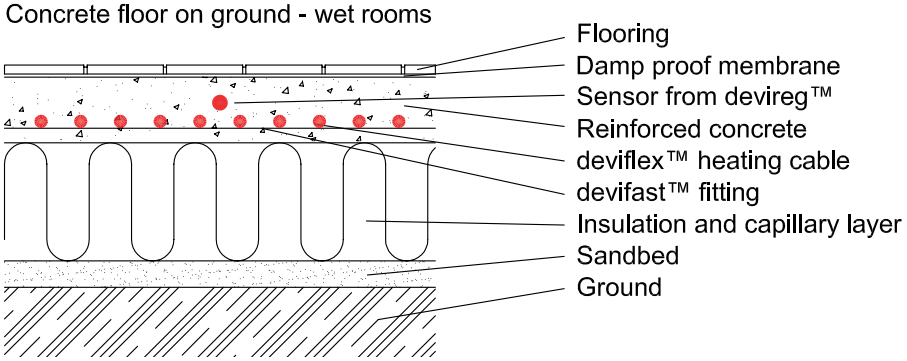
Finally, the insulation must comply with general and local regulations.

In connection with wet rooms (bathrooms etc.) a damp proof membrane should always be used in order to prevent moisture from entering the floor construction.

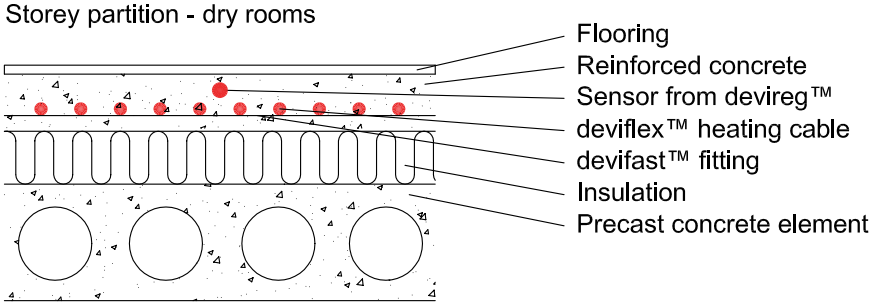
Concrete floor on ground - dry rooms



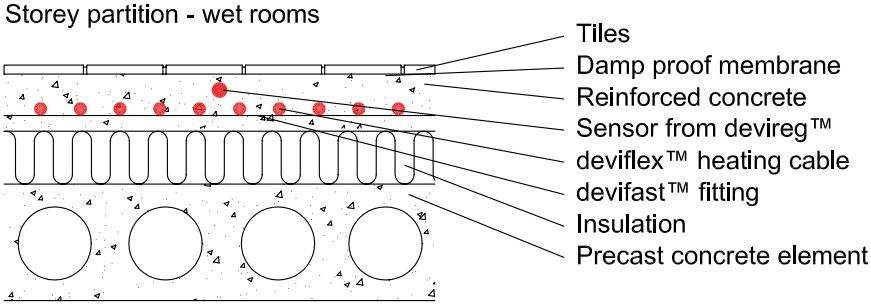
Concrete floor on ground - wet rooms



Storey partition - dry rooms



Storey partition - wet rooms



For more detailed installation instructions, please refer to the paragraph “General installation guide”.

Floor surfaces

Nearly all types of floor surfaces are suited for floors in which heating cables have been installed, but the supplier of the floor surface should always be consulted with regard to the adhesives to be used etc. The supplier’s instructions must be very carefully followed when wooden floors are installed directly on concrete constructions in which floor heating has been installed. For further information about heating in wooden floors, please refer to the paragraph “Wooden floors”.

Flooring materials with a high insulation value, like thick wool carpets, can limit the heat distribution from the floor. In these cases, please consult the supplier of the flooring material for further information.

Example

The heat loss in a 20 m^2 kitchen is 1200 W. The floor is to be covered with tiles. Cupboards etc. will cover 7 m^2 of the floor area. This leaves 20 m^2 - 7 m^2 = 13 m^2 to install the cables.

1) The required installed output should be 30% higher than the calculated heat loss: 1200 W x 1.3 =1560 W.

2) Choice of nearest cable: If we choose the deviflex™ DTIP-18, the nearest cable is 1625 W, 90 m.

3) Calculation of C-C distance: 13 m^2 x (100 cm/m)/(90 m) = 14.44 cm. By means of devifast™ fitting bands we install the cable with a C-C distance of 15 cm.

4) Choice of thermostat for the total heating system: We recommend the devireg™ 540 or 550.

1.3 Accumulating heating in concrete floors

DEVI's accumulating heating is designed to be used on the ground floor of houses, offices, and factories where there is an opportunity to use electricity during low tariff periods. The heating cables are embedded in a thick layer of concrete (7-15 cm) that accumulates the heat produced during the low tariff period.

Installed output
As already described in the previous paragraph the heat loss in a room needs to be known in order to calculate the installed output for accumulating heating.

To ensure that the system responds quickly a safety factor of approx. 1.3 has to be included in the calculation.

A low tariff period of e.g. eight hours means that the cables/mats have eight hours to generate the required amount of heat to be released over approximately the next 16 hours before the next low tariff period sets in.

The following equation is used to calculate the total required output for accumulating heating systems:

$$\frac{\text{Calculated heat loss x T x C}}{\text{t}}$$

Where:

T = hours of use (24)
C = security factor, approx. 1.3
t = Period of heat generation (time of low tariff availability), hours.

Normally, the installed output of an accumulating heating system is 125-200 W/m^2. If the calculation reveals an installed output over 200 W/m^2, the heating system should be supplemented by direct rim zone heating.

Rim zone heating
Rim zone heating fulfils the following purposes:

1. In houses with large glass and door surfaces it protects against cold drafts.
2. In houses with high heat losses it functions as a supplementary heat source.

A rim zone area is an area where the output per square metre is increased so more heat is generated in the rim zone area. This may be done by laying the cable in front of a large glass surface and decreasing the C-C distance until the required output is achieved. The width of a rim zone area is usually 0.5–1.5 m. The recommended output in a rim zone area is 200-250 W/m^2.

Rim zone areas require separate thermostats and sensors to control them. The rim zone heating can be regulated by a thermostat with a combined room and floor sensor or a thermostat with a floor sensor alone.

As a rim zone system is a directly acting heating system, it should not be covered by more than 3 cm of concrete. Together with the high output this will ensure that it responds quickly and efficiently to temperature changes.

With regard to wooden flooring, please refer to the paragraph "Wooden floor".

Product choice
When DEVI's accumulating heating system is installed, the deviflex™ with a minimum output of 18 W/m should be used. Besides, the devifast™ fitting bands will ensure a quick and easy installation.

Alternatively, the devimat™ (a pre-prepared cable mat) with an output of up to 200 W/m² can be used.

To control the temperature of the accumulating heating system a thermostat from the devireg™ 700 series should be used.

The devireg™ 700 series consists of electronic controls designed to save energy and regulate the floor storage heating during low tariff periods. The devireg™ 700 series consists of two types of interacting thermostats:

1. The master unit, which is connected to an outdoor sensor in order to constantly measure the outdoor temperature. The devireg™ 700 and 750 are master units.
2. The slave unit, which has a floor sensor measuring the remaining heat in the floor and limiting the floor temperature. The devireg™ 751/752/753 and 754 are all slave units.

The devireg™ 700 or 750 can control the temperature in as many as 400 different rooms or areas via slave units.

Installation
Accumulating heating cables must have a minimum output of 18 W/m and the maximum output must not exceed 200 W/m².

A suitable insulation should be laid below the cables according to the building standards. When the cables are laid, special care must be taken to avoid that they get into contact with the insulating material or become enveloped by it in any way.

The cables are attached to devifast™ fitting bands or the steel reinforcement with an appropriate C-C distance.

As the rim zone system is a directly acting heating system, it should not be covered by more than 3 cm of concrete. Together with the high output this will ensure that it responds quickly and efficiently to temperature changes.

It is important that the floor construction is well insulated so the downward heat loss is kept to a minimum.

Another important element is the vertical rim zone insulation.
This insulation must be efficient in order to prevent heat from being transported to the walls or adjoining rooms. Besides, it should be able to respond to the horizontal expansibility of the floor construction.

Finally, the insulation must comply with general and local regulations.

In connection with wet rooms (bathrooms etc.) a damp proof membrane should always be used in order to prevent moisture from entering the floor construction.

For further information about installation, please refer to the paragraph “General installation guide”.

Floor surfaces
Nearly all types of floor surfaces are suited for floors in which accumulating heating has been installed but the suppliers of the floor surface should always be consulted with regard to the temperature tolerance and the adhesives to be used etc. The supplier’s instructions must be very carefully followed when wooden floors are laid directly on concrete constructions in which accumulating heat has been installed. Particularly important is the information about the maximum temperature tolerance of the floor surface material.

Floor surface materials with a high insulation value, like thick wool carpets, may limit the heat distribution from the floor. In these cases, please consult the supplier of the floor surface material for further information.

Example 1
A 13 m² office with an available floor space of 12 m² has to be heated with an accumulative heating system. The total heat loss has been calculated to 650 W.
The entire low tariff period lasts for 10 hours (8 hours in the evening and 2 hours during the day).

1) Required installed output:

$$\frac{650\ \text{W} \times 24\ \text{hours} \times 1.3}{10\ \text{hours}} = 2028\ \text{W}$$

2) Choice of nearest cable: if we choose the deviflex™ DTIP-18, the nearest cable is 2135 W, 118 m.

3) Calculation of C-C distance: 12 m² x (100 cm/m)/(118 m) = 10.17 cm. By means of devifast™ fitting bands we install the cable with a C-C distance of 10 cm.

4) Choice of thermostat: the accumulating heating system can be controlled by the devireg™ 750.

Example 2
In this example the low tariff period lasts for 8 hours. A 26 m² storage has a usable floor space of 23 m². The total heat loss has been calculated to 1320 W.

1) Total required installed output:

$$\frac{1320\ \text{W} \times 24\ \text{hours} \times 1.3}{8\ \text{hours}} = 5148\ \text{W}$$

2) Choice of nearest cable: if we choose the deviflex™ DSIG-20, the nearest cable is 4565 W, 228 m.

The chosen cable cannot provide the required output. Therefore, a rim zone system below the windows

could be a satisfactory solution.
If we subtract the 4565 W from the required output (5148 W), we can see that the required output still exceeds the output of the cable as we need an additional 583 W.
As the rim zone system is a directly acting heating system as opposed to accumulating heating, the 583 W must be converted back to their original status.

This is best done by dividing the 583 W of storage heat by 3 (24 h/8 h) which means that the security factor is still included in the final result.

583 W/3 = 194 W of directly acting heat.

If we choose the deviflex™ DTIP-18, the nearest cable is 270 W, 15 m.

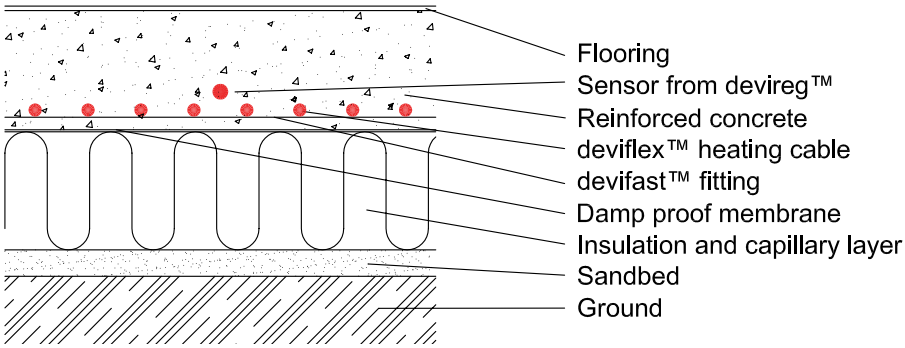
3) Calculation of C-C distance: 23m² x (100 cm/m)/(228 m) = 10 cm.

4) The C-C distance of the rim zone. If the area of the rim zone is 0.5 m x 2.4 m = 1.2m², this gives a c-c distance of : 1.2 m² x (100 cm/m)/(15 m) = 8 cm.

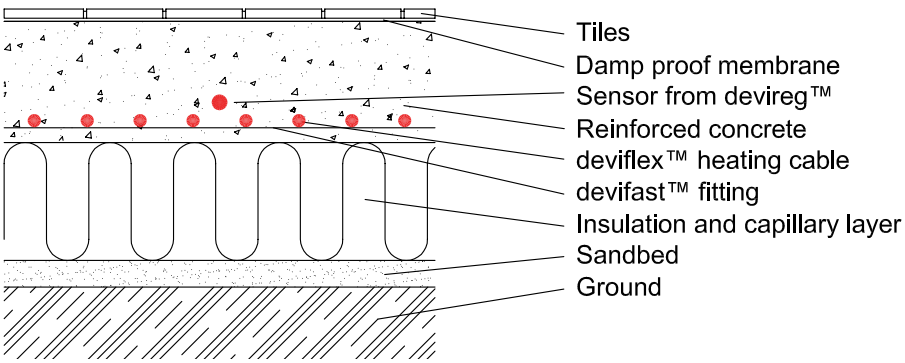
5) Choice of thermostat: in this example, the accumulating heating system can be controlled by a devireg™ 750.

The rim zone can be controlled by a devireg™ 540.

Floor with accumulating heating - dry rooms



Floor with accumulating heating - wet rooms



1.4 Heating in renovated floors and thin floors

DEVI has designed a special system for house renovations where the construction height of the floors needs to be low. The devimat™ application requires a height of approx. 12 mm, including the floor surface. The system can be installed on the existing tiles, wooden floors or concrete floors.

Typical areas of use are kitchens and bathrooms but the heating system can be used anywhere in a house in connection with a renovation.

Installed output
The installed output per m² is calculated in the same way as for direct heating in concrete floors. Please refer to the relevant paragraph.

Product choice
When the installed output per m² has been calculated, one of the following heating elements may be installed in the renovated floors:

1. The devimat™ 100 W/m².
2. The devimat™ 150 W/m²
3. The deviflex™ with a max. of 10 W/m

If the floor height is crucial, the devimat™ is recommended. Since the devimat™ is only 3-5 mm thick (including tile glue/adhesive) and since it is installed directly on the existing floor, the increase in the floor height will be minimal. The net of the devimat™ is self adhesive and ensures a quick and easy installation.

If the floor height is not crucial, the deviflex™ cables are recommended. This is often the case if the old floor is removed, before the new floor surface is installed.

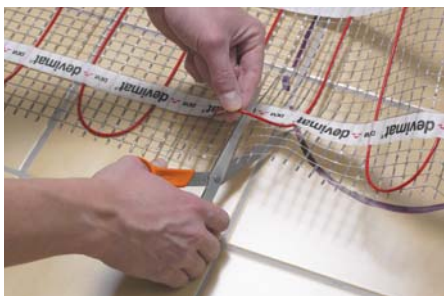
If there are any wooden constructions under or above the devimat™, the devimat™ 100 W/m² must always be used. For further information about heating in wooden floors, please refer to the paragraph “Heating in wooden floors”.

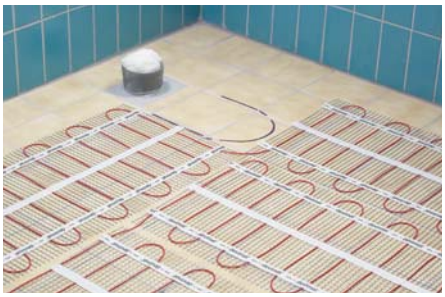
To exploit the optimal comfort and economy of the system thermostats with simple or intelligent timers should be used – the devireg™ 540 or the devireg™ 550.

Installation

Renovation with devimat™
The total thickness of the devimat™ (including tile glue/adhesive) is 3-5 mm. The width covers 50 cm while the length ranges from 1 to 22m. The net of the devimat™ is self adhesive and ensures a quick and easy installation.

It is very important to choose a mat with the right dimensions since the mat cannot be shortened. To make your choice easier you can use the DEVI matplanner – a programme especially designed to help choose the right devimat™. The DEVI matplanner can be found on www.devi.com.





The installation of the devimat™ should be started from the wall and directed towards the opposite wall.Here, the mat needs to be turned back by cutting the net of the devimat™ (NB! DO NOT cut the cable!). This process has to be continued until the entire surface has been covered with the devimat™.

Renovation with deviflex™ cables
If the floor height is not crucial, deviflex™ heating cables 10 W/m can be used. The max. C-C distance is 10 cm, ensuring that cold zones on the floor surface are avoided. Floor heigt will be 10-30 mm.

When deviflex™ heating cables are to be installed, we recommend the use of devifast™ fitting bands. The devifast™ is designed so the C-C distance can be chosen at intervals of 2.5 cm, e.g. 5 cm, 7.5 cm, or 10 cm.

The min. bending diameter for a heating cable is 6 times the cable diameter.

It is also possible to attach the cables directly to wire mesh netting with a diameter of 1 mm and a masking size of 20 x 20 mm. This net is attached to the existing floor. Alternatively, the cables may be attached to the net with a glue gun. If a thermostat with a floor sensor is used, the sensor must be protected by a plastic pipe with a min. diameter of 9 mm. The bigger the diameter of the pipe is, the easier it is to place in the sensor. The pipe has to be sealed at the end so the concrete does not enter it.

If the cable or heating mat is laid on an existing wooden floor, it is necessary to ensure that the construction is stable even under heavy load. If the floor heating is installed on an existing wooden floor, a damp proof membrane should be used in order to prevent any moisture absorption from the compound.

For further information about installation, please refer to the paragraph “General installation guide”.

Floor surfaces
All floor surfaces are well suited for floor heating but the cables must be covered with at least 20-25 mm of concrete if the covering material consists of wood or plastic. The supplier of the floor surface should be informed that heating cables are being installed and consulted with regard to the glue to be used etc. The manufacturer’s instructions must be followed very carefully when installing DEVI’s floor heating system in wooden floors.

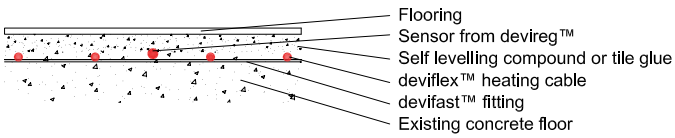
Particular attention should be paid to the installation and the maximum temperature tolerance of the floor surface. The maximum temperature permitted on a wooden floor surface installed directly on top of a concrete base is 27°C.

Example
A 6 m² bathroom is to be renovated. The usable floor space is 5 m². The floor surface is to consist of tiles. The DEVI system is the only heating system in the bathroom.

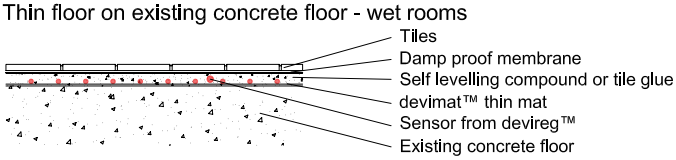
1) We choose the devimat™ DSVF-150 for 5 m² with a total output of 750 W/m².

2) We choose a thermostat with combined floor and room sensors and a timer function: the devireg™ 540.

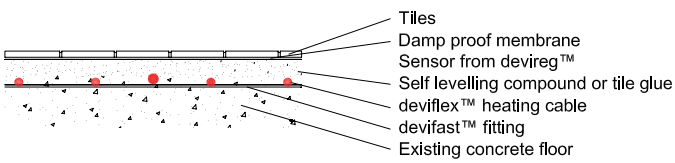
Renovated floor on existing concrete floor - dry rooms



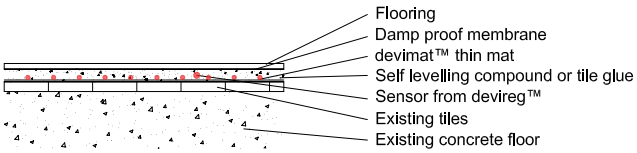
Thin floor on existing concrete floor - wet rooms



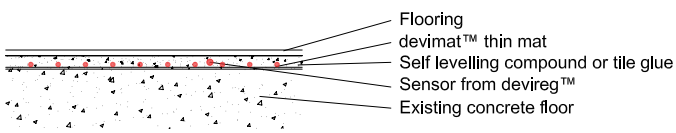
Renovated floor on existing concrete floor - wet rooms



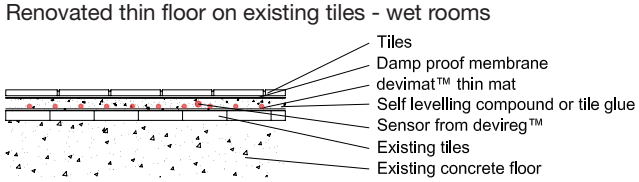
Renovated thin floor on existing tiles - dry rooms



Thin floor on existing concrete floor - dry rooms



Renovated thin floor on existing tiles - wet rooms



1.5 Heating in wooden floors

DEVI's heating system can be installed in all kinds of wooden floors as long as the installation prefaces are observed. The devireg™ 550 or 540 electronic thermostats, by means of which the temperature of the floor may be limited, ensure that the temperature in the floor construction always corresponds to the tolerance level that the manufacturer of the floor surface has recommended.

Installed output
The installed output per m² is calculated in the same way as for direct heating in concrete floors. There are few limitations to be observed when installing floor heating in the wooden floors, though:

1. The installed output in wooden floors on joists must not exceed 80 W/m².
2. The installed output in wooden floors lying on or under concrete must not exceed 100 W/m².
3. The installed output in floors lying om wood must not exceed 100 W/m².

If the calculation reveals an installed output exceeding 80 W/m² and 100 W/m² respectively, an additional heating system has to be used to ensure a comfortable temperature in the room.

Product choice
We recommend the deviflex™ with a max. output of 10 W/m or the devimat™ 100 (100 W/m²).

To control the heating in the wooden floors the devireg™ 550 or devireg™ 540 are the better choices. Both of these thermostats are equipped with built-in room sensors regulating the room temperature and floor sensors limiting the temperature in the floor. The temperature on the floor surface should not exceed 27°C. As an extra safety factor the devireg™ 550/540 will disconnect the heating system if the sensor should fail.

Installation

Under or on wooden floors

When heating is installed in wooden floors on concrete or on existing wooden floors, the surface temperature of the wooden floor should not exceed 27°C. Therefore, a floor sensor should always be used in order to control the temperature in the floor. The floor sensor has to be connected to the electronic thermostat with the temperature limiting feature. We recommend the devireg™ 550 or devireg™ 540 for applications in wooden floors.

The maximum installed output should not exceed 100 W/m².

The supplier of the wooden floor should be informed that heating is being installed so the right type of adhesive is used etc. The floor manufacturer's recommendations regarding the installation of floor heating installation under wooden floors should always be followed.

Some suppliers have certain requirements regarding the start up of a heating system under wooden floors. For example before the wooden floor is laid:

- The floor heating system must have been switched on for at least 3 weeks.
- The system must have been working under max. output for 4 days.
- After the wooden floor has been installed, the concrete temperature must be below 18°C.
- The floor temperature must be increased slowly during the first week.

Wooden floors on joists

When heating is installed in wooden floors supported by joists, the heating cables should not exceed

10 W/m and the maximum output should not exceed 80 W/m². The floor heating in floors on joists will work optimally if there is a distance of 3-5 cm between the cables and the flooring.

The heating cables are installed on mesh netting (chicken wire), which is fastened to the sleepers. The mesh netting is installed so there is a minimum distance of 30 mm between the netting and the under side of the floor surface.

The heating cable must not get into direct contact with the insulation and it should not be allowed to touch the woodwork for long periods at a time. The distance between the cable and the wooden planks and joists should be at least 30 mm. A path should be made every time the cable crosses a joist and the path should be covered with metal (i.e. aluminium tape).

There must never be more than one cable in each path. The bending diameter of the cables must not be less than 6 times the cable diameter. The cable should be attached to the mesh netting at 30 cm intervals.

Types of floor surfaces
DEVI's floor heating systems may be used in connection with all known types of wood, both in plank form and laminated. It is important that the manufacturer's recommendations for maximum temperatures are carefully followed.

With regards to the thickness of the wooden floor, floor heating should only be installed as a total heating system if:

1. The maximum thickness of soft wood (density 400-600 kg/m³ – pine etc.) is 2 cm.
2. The maximum thickness of hard wood (density over 600 kg/m³ – beach, oak etc.) is 3 cm.

Example
In a 20 m² kitchen the calculated heat loss is 1100 W. The usable floor area is only 15 m². The floor is wood on concrete.

1) The total required output should be 30% higher: 1100 W x 1.3 = 1430 W.

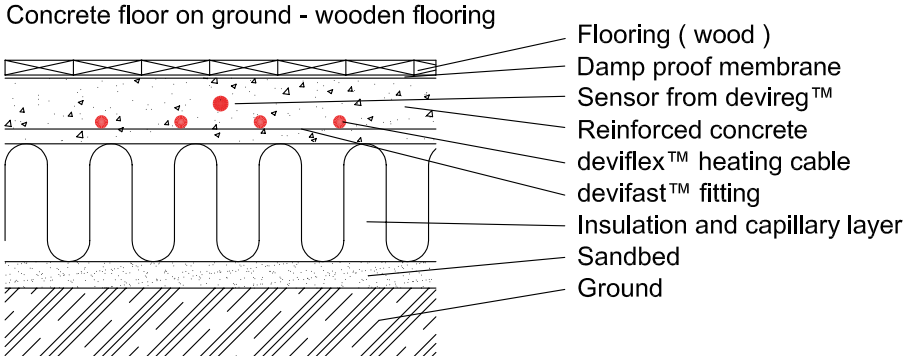
2) Choice of cable with the nearest output: DTIP-10, 1500 W, 150 m.

3) Total installed output per m²: 1500 W/15 m² = 100 W/m². This is appropriate for floor heating underneath wooden flooring.

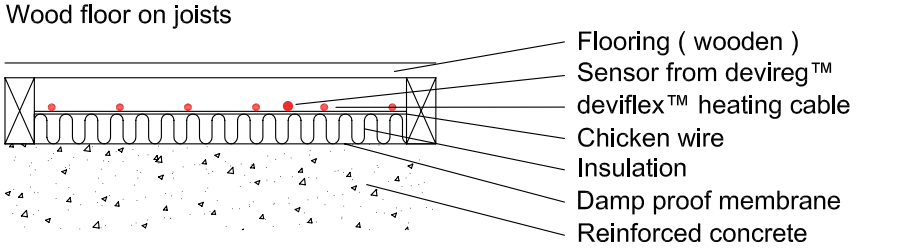
4) Calculation of C-C distance: as this cable covers up to 15 m², the calculated C-C distance is 15 m² x (100 cm/m)/(150 m) = 10 cm.

5) Choice of thermostat: the devireg™ 550.

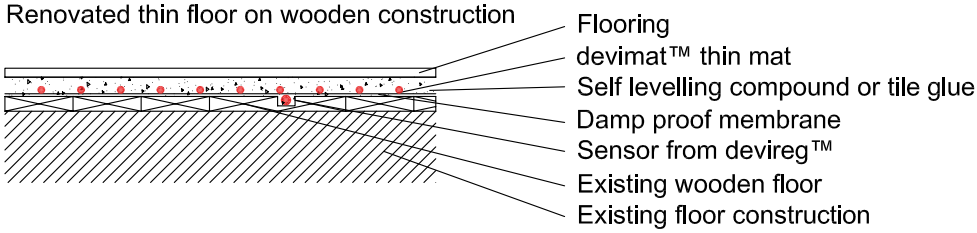
Concrete floor on ground - wooden flooring



Wood floor on joists



Renovated thin floor on wooden construction



1.6 Product choice

The table below can be used as a guide for choosing the heating element.

Purpose of use	Normal output/m²	Max. output/m²	deviflex™ max. 18 W/m	deviflex™ max. 10 W/m	devimat™ 120	Thin devimat™ 100	Thin devimat™ 150
Direct heating, new construction	70-120	150	X		X		
Direct heating, renovation or thin floors	100-150	150		X		X	X
Accumulating heating	125-200	200	X				
Rim zone heating	200-250	250	X				
Heating in wooden floors	80-100	100		X		X	
Heating in wooden floor on joists	60-80	80		X			

Choice of devireg™ thermostat

DEVI has developed a wide range of devireg™ electronic thermostats to control the DEVI heating systems. Electronic thermostats regulate the temperature quickly and precisely and by choosing the optimal thermostat both comfort and financial benefits may be achieved.

Before choosing a devireg™ thermostat the following parameters should be considered.

Sensor type

1. **Floor sensors** are recommended with supplementary heating systems to ensure a pleasant floor temperature.
2. **Room sensors** are recommended where the DEVI heating system is the only heat source in the room, and where the heating system is designed to supply full room heating.
3. **A combination of both** floor and room sensors is recommended in applications where the floor temperature needs to be limited but where the heating system is designed to supply full room heating, e.g. wooden floors.

Installation

The devireg™ thermostats can be installed on the wall, in the wall or on a DIN rail. If the thermostat uses an external sensor type, the thermostat can be mounted both in and outside the room. This is useful where the user should not be able to adjust the control, e.g. hotels, schools etc. Thermostats with room sensor on both floor and room sensors must always be installed in the room with the heating element.

Relay type

All devireg™ thermostats are equipped with a relay and therefore, they are able to control a contactor. Without an extra contactor each thermostat has a maximum load of the total output of the heating element. This can be calculated as: maximum output = voltage power supply x relay ampere. (Example: 230 V x 16 A = 3680 W).

Timer thermostats

The devireg™ 550 is equipped with an intelligent timer while the devireg™ 540 has an ordinary timer.

The intelligent part is that the devireg™ 550 automatically finds out when to start heating in order to reach the user set temperature at the desired time. This will be adjusted during the year, depending for example on the thermal conditions of a room.

Being equipped with an ordinary timer system, the devireg™ 540 does not start heating until a given user set time of the day.

Network

When more devireg™ 550's are installed in a house or an apartment, they can be combined in a network where one of the devireg™ 550's controls the others. This network function may also be used in combination with the devicom™ – a device allowing a simultaneous monitoring and regulation of up to 31 devireg™ 550's via PC.

2.1 General information

DEVI's ice and snow melting system consists of deviflex™ or devi-iceguard™ heating cables or devimat™ heating mats, devireg™ thermostats, and installation accessories. DEVI's ice and snow melting systems are applied for roof construcions and ground areas.

Provides safety
DEVI's ice and snow melting system is designed to provide safety for people, vehicles, and buildings safety through safe walking and driving during winter and safety in terms of less damage to buildings.

The system is flexible
DEVI's ice and snow melting system works well with most common surface covering materials such as asphalt, concrete, and tiles. Besides, it can clear ice and snow from all types of roof constructions, roof gutters, downpipes, and valley gutters.

Works automatically
DEVI's ice and snow melting system operates fully automatically. It automatically registers the need for ice and snow melting and it switches the heat on and off as required.

An economical alternative
The devireg™ thermostats with advanced moisture sensors ensure that optimal results are achieved with the least possible amount of energy. The costs of installing and running DEVI's ice and snow melting system are low when the preventive advantages of the system are taken into consideration, i.e. snow shovelling and salting becomes unnecessary. Furthermore, the repairing costs caused by ice, snow and salt are saved.

Provides comfort
With DEVI's ice and snow melting system the area is kept free from ice and snow at all times so heavy salting, snow shovelling or frost damages are avoided.

2.2 Ground applications

The most common DEVI ice and snow melting applications on ground are car parks, driveways, pavements, outdoor steps, loading platforms, and bridges.

Installed output

When the required W/m² of an ice and snow melting system is to be determined, there are several considerations to be made:

1. The place where the system it is to be installed – geographical location and specific application.
2. The requirements the system is to meet, e.g. the time of ice and snow melting.

The installed rating for Denmark is 200-250 W/m². In comparison the corresponding rating for Russia is 250-500 W/m².

In places such as bridges and loading platforms the cables are also susceptible to the influence of cold weather and wind from both above and below. In these places the output should be increased by up to 50% to compensate for the extra amount of cold. Therefore, it is advisable to use an appropriate insulation material below the cables in order to minimise the downward heat loss. Where it is not possible to insulate below the heating cables, we recommend an output of 300-500 W/m².

Typical installed ratings of various ground applications are shown in the table below.

Area	Output in Denmark	Output in Russia
Car parks	200-250 W/m²	250-300 W/m²
Driveways	200-250 W/m²	250-300 W/m²
Pavements	200-250 W/m²	250-300 W/m²
Outdoor steps, insulated	200-250 W/m²	250-300 W/m²
Loading ramps, insulated	200-250 W/m²	250-300 W/m²
Bridges, insulated	200-250 W/m²	250-300 W/m²
Outdoor steps, not insulated	300-375 W/m²	300-400 W/m²
Loading ramps, not insulated	300-375 W/m²	300-400 W/m²
Bridges, not insulated	300-375 W/m²	300-400 W/m²

The general guidelines for choosing the output for the installation are presented below.

Outdoor dimensioning temperature	Output on ground	Output on ramps, bridges (not insulated)
-10°C	200 W/m²	250 W/m²
-15°C	250 W/m²	300 W/m²
-20°C	300 W/m²	350 W/m²
-25°C	350 W/m²	400 W/m²
-30°C	400 W/m²	450 W/m²
-35°C	450 W/m²	500 W/m²
-40°C	500 W/m²	550 W/m²

The installed output should be higher if:

1. The installation is placed in an area with frequent wind during winter. A wind speed of 10 m/s results in an additional relative temperature drop of approx. 5°C. The higher the wind speed, the bigger the temperature drop.

2. The installation is placed on a high geographical location. We recommend adding 50 W/m² per every 1000 m for locations over 1000 m above sea level.

3. Significant snowfalls are observed in the area. If there is more snow than what equates to 6.3 mm of water every 6 hours, 50 W/m² should be added.

Products for ground applications
For ice and snow melting applications the deviflex™ heating cables with a minimum output of 17 W/m or devimat™ cable mats with a minimum output of 200 W/m² can be used. For applications in asphalt we recommend deviflex™/devimat™ DSVK.

To control the system the devireg™ 850, 610, 330, or 316 with a ground and/or air sensor should be used.

Installation under asphalt
There are two main installation methods for asphalt:

1. Cables are covered with sand or concrete before the asphalt is applied.
   Before the asphalt is applied, a thin layer of sand or concrete (at least 2 cm) should be used to cover the top of the cables to protect them from the heat of the asphalt. Allow the asphalt to cool to a temperature of 130°C-140°C before it is applied.

For this installation method we recommend a deviflex™ cable such as the DSIA or the DSIG.

2. Asphalt is applied directly onto the cables or mats.

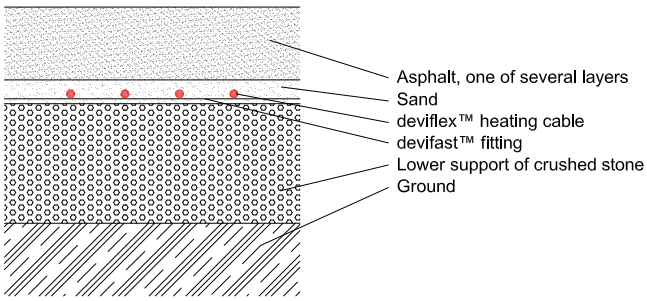
DEVI recommends the deviflex™ or devimat™ DSVK for asphalt installations as it can resist 240°C for a short time. With this type of cable it

is not necessary to cover the cable with sand. This reduces the time and installation costs. In order not to damage the cables, heavy machinery (rollers or asphalt laying machines) should not be used on the cables.

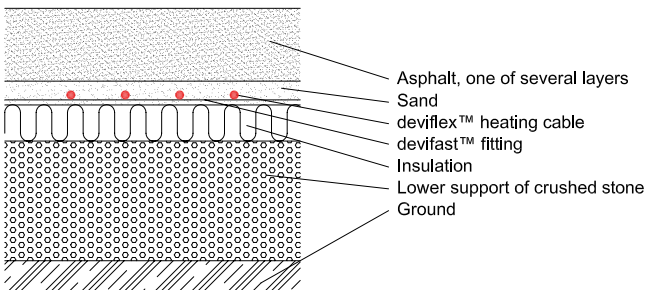
The asphalt should have a minimum thickness of 5 cm measured from the top of the deviflex™ heating cables.

An electrician should measure the cable resistance and the insulation resistance before and after the asphalt is applied.

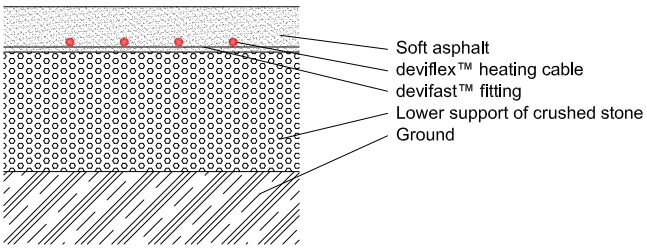
Asphalt



Asphalt (with insulation)



Soft asphalt



Installation under concrete tiles
Special care must be taken not to damage the heating cables when they are installed under tiles.

The area must be completely level, free of stones or other sharp objects and all holes should be filled.

The heating cables must be installed close to the tiles, typically in a layer of sand (2-3 cm).

Installation under concrete
Installing deviflex™ cables or devimat™ mats in concrete is similar to the procedure for tiles or asphalt.

The cables should be well secured with devifast™ fitting bands (which may be fastened to the metal armouring) so they are not dislodged when the concrete is applied. The concrete must cover the cables completely without leaving any air pockets.

The concrete mixture must not contain sharp stones as these may damage the cables.

The concrete should be allowed to set for 30 days before the heating system is turned on.

An electrician should measure the cable resistance and insulation resistance before and after the concrete is applied.

In places where the heating cables are to cross expansion joints, the cables must not be subject to mechanical strain in connection with movements in the construction.

Car parks
Normally, a car park is a large area where fast ice and snow melting is required. There are a number of advantages to be gained from installing an ice and snow melting system. It reacts quickly and efficiently against snow and appears to be an excellent preventive feature against ice. The problem of removing snow from occupied parking bays is eliminated and as an extra advantage the car park may be used to the full.

For this kind of ice and snow melting system to work efficiently it should incorporate the devireg™ 850 with star/delta function and a deviflex™ cable or a devimat™ heating mat.

Example
An ice and snow melting system has to be installed in a 150 m² car park in Denmark.

For that application we choose a deviflex™ DSIG-20 and an installed output of 250 W/m², which is sufficient for Danish climate conditions.

1) Calculation of total required output: 150 m² x 250 W/m² = 37.5 kW

2) Choice of nearest DSIG cable(s): for this purpose it will be 12 deviflex™ DSIG-20 heating cables with 3175 W, 158 m, 400 V. The total effect will be 38.1 kW.

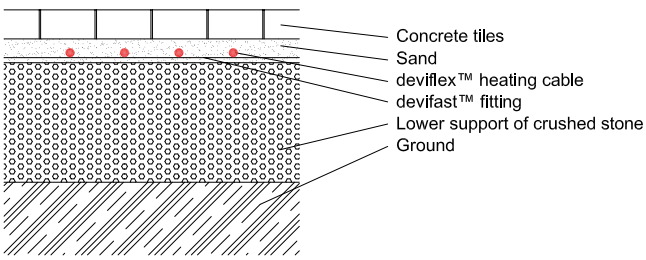
If the installation is equipped with a star/delta switch, the number of cables must be dividable by 3 or the load should be evenly distributed on 3 phases. This ensures a steady load of the phases.

3) Calculation of C-C distance:

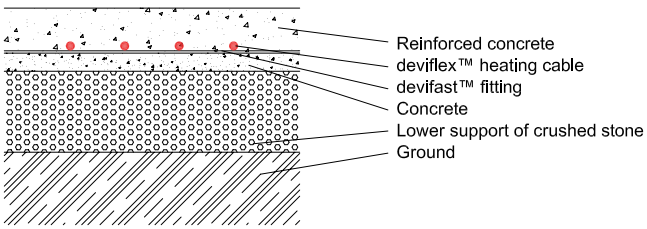
$$\text{C-C} = \frac{20\ \text{W/m} \times 100\ \text{cm/m}}{250\ \text{W/m}^2} = 8\ \text{cm}$$

4) Choice of thermostat:
We choose the devireg™ 850 because of the size of the area.

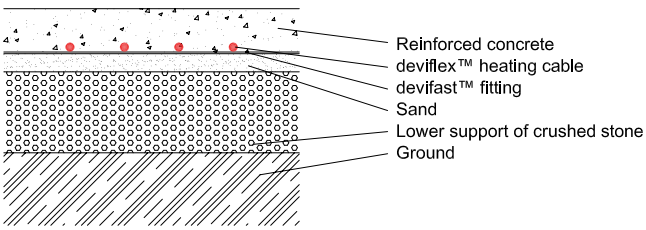
Concrete tiles



Concrete (cables on concrete)



Concrete (cables on sand)



Driveways
One of the great advantages of an ice and snow melting system is the automatic clearing of driveways keeping them passable at all times - night and day. This is especially important in specific situations where a free passage is needed for ambulances or other types of vehicles.

There are two options when an ice and snow melting system is installed in a driveway:

1. Covering the entire area with heating cables or mats.
2. Covering just the area affected by car tyres.

We recommend the first option for all major driving areas with heavy traffic. The cleaning of snow and ice formations, which can occur with the second option, will be complicated.

The second option is recommended for minor areas, like driveways to private garages. If the driving area has a slope, we recommend the entire area be covered with heating cables or mats.

When installing ice and snow melting systems on steep slopes it may be necessary to provide some form of drainage for the melted water at the bottom of the slope. The drain system should also be protected against ice formations.

Example
In this example we have chosen a medium-sized driveway with a length of 10 m and a width of 2 m. The cables are to be installed in the two tyre tracks with a width of 0.5 metre each.

For this application the installed output is 250 W/m² and the chosen cable is the deviflex™ DSIG-20.

1) Calculation of the area where the cable is to be installed:
10 m x 0.5 m x 2 = 10 m²

2) Calculation of the total output for the area: 10 m² x 250 W/m² = 2500 W.

3) Choice of cable: The deviflex™ DSIG-20, 2520 W, 126 m heating cable.

4) Calculation of C-C distance:

$$\frac{10\ m^2 \times 100\ cm/m}{126\ m} = 7.9\ cm$$

5) Choice of thermostat: Since the area is rather small, we choose the devireg™ 330 with a temperature sensor.

Pavements
An ice and snow melting system can ensure a safe walking area for pedestrians. Apart from keeping pedestrian streets free from snow the snow melting system provides clean entrances for all shops.

Outdoor steps
An ice and snow melting system may be used as an efficient preventive feature against slippery and dangerous steps.

We recommend that outdoor steps are insulated if they are open underneath and susceptible to cold. If, on the other hand, the steps are solid, they need not to be insulated.

The output/m^2 in the steps should always be higher than the output/m^2 in the area immediately before the steps. If this is not observed, accidents may occur if the area before the steps is free of ice while the steps are slippery.

When calculating the cable length for a step application, remember to take into account the extra piece of cable which is led down the front of each step.

The cables are laid backwards and forwards in evenly spaced loops along the step.

As the heating cables are not installed on the vertical part of the steps, the steps, the first cable loop should be laid as close as possible to the edge of each step (5 cm) to ensure an efficient melting of ice.

When the cables are installed all stones or sharp objects should be removed from the surface as they may damage the cables.

The cables are installed directly on the concrete and must be covered with 3-5 cm of concrete.

Example
We have an example of steps:
12 steps with a depth of 0,32 m, a height of 0,17 m and a stair width of 1,00 m.

With a DTIP - 18 heating cable and a required output of 250 W/m^2 the C-C distance will be:

$$\text{C-C} = \frac{18\text{W/m} \times 100\text{cm/m}}{250\ \text{W/m}^2} = 7.2\ \text{cm}$$

As each step is 0,32 m deep, there is room for 4 cable runs on each step amounting to 4 m of cable per step.

4 m of cable x 12 (steps) = 48 m of cable plus the cable running down the front of each step: 12 x 0.17 m = 2 m.

This gives a total of 50 m cable and therefore, a deviflex™ DTIP-18 cable, 935 W and 52 m, is appropriate.

The total area of the steps is:
12 x 1 m x 0,32 m = 3.84 m^2

And therefore, the installed rating is:
935 W/3.84 m^2 = 244 W/m^2

If there is any cable left, it should be installed in the area in front of the steps.

Loading areas
Loading areas must be safe to work on and therefore, they should be kept free of ice and snow. DEVI's ice and snow melting system reduces the risk of accidents and ensures that the work can be done at all times.

Loading ramps are generally open and consequently, they are more susceptible to the cold weather. We recommend that all loading areas and loading platforms are well insulated to avoid heat loss downwards. Where it is not possible to insulate below a loading area, the output per m^2 must be increased to 300-400 W/m^2.

Example – loading areas
DEVI's ice and snow melting system has to be installed in a 2.5 m x 15 m non-insulated loading area.

1) Choice of product and required output per m^2: the cable to be used is a deviflex™ DSIG-20 and the installed rating is 350 W/m^2.

2) Calculation of area: 2.5 m x 15 m = 37.5 m^2

3) Calculation of total required output: 37.5 m^2 x 350 W/m^2 = 13125 W.

4) Choice of cable: three deviflex™ DSIG-20 cables, 4575 W, 229 m, 400 V are chosen for this installation.

5) Calculation of the total length of the cable to be installed: 3 x 229 m = 687 m.

6) Calculation of C-C distance:

$$\text{C-C} = \frac{37.5\ m^2 \times 100\ cm/m}{687\ m} = 5.5\ cm$$

Bridges
Bridges are even more susceptible to cold weather than loading areas as they are almost always completely open. This reduces the effect of the heating cables considerably and therefore, the under side of bridges should be well insulated. Where this is not possible, the output per m^2 should be increased to 300-400 m^2.

The devireg™ 850 with star delta function and the deviflex™ 400 V heating cable will in most cases be the most appropriate ice and snow melting system for bridges.

The heating cables should never be laid across the section joining of a bridge.

2.3 Roof applications

DEVI's ice and snow melting system for roofs and roof gutters can be installed in virtually any type of roof construction where there is a need to prevent melt water deposits in roof gutters and reduce damages to constructions like frozen facades and roofs.

The ice and snow melting system should be installed along the edge of the roof or in places where there is a risk of ice and snow formations. In roof gutters and downpipes damage is prevented by an efficient and free draining of melt water, which naturally ensures that the system functions satisfactorily.

Electronic devireg™ thermostats ensure that optimal results are achieved with the least possible amount of energy. In order to achieve these results sensors and thermostats read the weather with total accuracy, automatically switching the heating on and off at exactly the right moment.

The typical areas of use are roof constructions, roof gutters, downpipes, and valley gutters.

Required output

To determine the required output (W/m^2) of an ice and snow melting system for a roof it is important to consider the type of roof construction in question and the local weather conditions.

In general, all roofs fall into two categories:

1. A cold roof. A cold roof is a well-insulated roof with a low upward heat loss. A cold roof will typically cause ice formations in those periods when the sun melts snow formations on the roof.

2. A hot roof. A hot roof is not well insulated or/and the attic is used as a living area. Hot roofs melt the snow to a certain extent and the water from the melted snow then moves downwards to the edge of the roof where it freezes.

The installed rating in gutters should therefore be higher in hot roofs than in cold roofs. This will ensure efficiency, even at low temperatures.

For roof applications cables with 15-25 W/m are used. If the cables are installed on top of a roof by means of a meltable material, the maximum rating of the heating cable must not exceed 20 W/m.

The required output per m^2 will be similar to that of ground applications.

Gutters running along the edge of a cold roof, generally require 30-40 W/m. In comparison the required rating for hot roofs is 40-50 W/m. For these applications 2 or 3 deviflex™ cables can be chosen in order to obtain the necessary output per m, and in some cases even more.

For further information, please refer to the diagram below:

Area	Cold roof	Hot roof	Max. rating	Cable rating
Valley gutter, roof surface	200-250 W/m^2	250-300 W/m^2	300 W/m^2	15-25 W/m
Downpipes, plastic roof gutters	30-40 W/m	40-50 W/m	50 W/m	15-25 W/m
Downpipes, metal roof gutters	30-40 W/m	40-50 W/m	100 W/m	15-25 W/m
Downpipes, wooden roof gutters	30-40 W/m	40 W/m	40 W/m	15-25 W/m

Roof gutters and downpipes
The cable is led back and forth along the gutter as many times as necessary in order to achieve the needed output. Two lengths of cable (back and forth) is usually adequate.

In general, if the dimensioning outdoor temperature is above -20°C, you need:

- 2 lengths of cable in a gutter connected to a cold roof;
- 3 lengths of cable in a gutter connected to a hot roof.

If the dimensioning temperature is below -20°C, you need:

- 3 lengths of cable in a gutter connected to a cold roof;
- 4 lengths of cable in a gutter connected to a hot roof.

The heating cables can be installed in different ways in roof gutters and downpipes but in most cases the same cable is used for both roof gutters and downpipes.

In roof gutters the heating cables are fixed at the correct distance (C-C distance) by devifast™ spacing clips. In downpipes a metal chain is hung inside the pipe to which the devifast™ spacing clips are then attached. If the cable length does not exceed 50 cm, a metal chain is not needed but spacing clips are still necessary.

Alternatively, a rope can be used for installations in downpipes. In this case the cable is fixed with special metal clips.

If a self-regulating heating cable (the devi-iceguard™) is used for roof applications, it is usually enough to use 1 m of cable per 1 m of roof gutter and downpipe. With self-regulating heating cables it is not necessary to use a metal chain in the downpipe. The cable has to be protected from the sharp edges of the downpipe.

Example
The following example is intended for a plastic gutter with a length of 13 m and a 5 m long downpipe at the end.

1) Calculation of necessary cable length: two cable lengths in the gutter will require:

   2 x (13 m + 5 m) =
   36 m of cable.

2) Choice of cable: we have chosen a deviflex™ DTIP 18, 680 W, 37 m and by folding the cable, we are able to cover both the gutter and the downpipe with an installed output of 36 W/m.

In order to keep the cable in the correct position in the gutter, devifast™ spacing clips should be used. The cable in the downpipe should be attached to a metal chain.

3) Choice of thermostat:
   a devireg™ 316 with an outdoor sensor is suitable for this installation.

Valley gutters
The installation of heating cables in valley gutters typically concerns larger buildings. The heating cable is led backwards and forwards along the the gutter so the correct output per m^2 is achieved, similar to ground applications.

We recommend devifast™ fitting bands to fasten the cable in the valley gutter and devifast™ plastic cable holders to attach the cable to the metal chain in the downpipe.

The devifast™ is fixed by means of hotmelt or silicone.

Often several downpipes are placed in the middle of the valley gutter. If only a short length of the cable is led down the pipe devifast™ spacing clips should be used in order to avoid crossing cables.

If the cable is led all the way down the pipe, it must be supported by a chain hanging down from the top of the downpipe.

The hook or supporter bar of the chain must by no means be placed on top of the cables in the gutter.

Example
The following example is intended for a valley gutter with an area of 10 m x 0,30 m and a 3 m long plastic downpipe at the end.

We have chosen a deviflex™ DTIP-18 heating cable and would like an installed rating of 250 W/m^2.

1) Calculation of installation area:
   The installation area of the cable is:

   10 m x 30 cm = 3 m^2

2) Calculation of total required output:

   250 W/m^2 x 3 m^2 = 750 W

Remember the heating cable for the downpipe:

2 x 3 m = 6 m, 6 m x 18 W/m = 108 W

This gives the following total output:

750 W + 108 W = 858 W

3) Choice of cable: in DEVI's cable programme we find the deviflex™ DTIP-18, 935 W, 52 m to be the most appropriate cable for this example.

4) Calculation of C-C distance: the distance between the cables for the valley gutter is calculated as follows:

$$\text{C-C} = \frac{3\ \text{m}^2 \times 100\ \text{cm/m}}{52\ \text{m} - 6\ \text{m}} = 6.5\ \text{cm}$$

In order to keep the cable in the correct position in the gutter, devifast™ fitting bands and spacing clips should be used.

5) Choice of thermostat: a moisture sensor is chosen for the registration of ice and snow and therefore, a devireg™ 850 thermostat with a set of sensors for the roof and gutter system is chosen.

Roof constructions
During winter the following unpleasant phenomenon may appear (especially with hot roofs):
A large quantity of snow and ice accumulates on the unheated lower part of the roof. It gradually condenses and converts into a big massif of ice. In the spring or when the weather gets mild during winter, this massif can roll down the roof, damaging roof gutters and other roof constructions and creating a serious threat to everything or everybody standing next to the house.

A typical output for a roof is 250 W/m².

To prevent the accumulation of ice, heating cables should be installed in the lower part of the roof. When heating cables are installed on roofs, the installation is often combined with a snow-stopping unit to prevent snow sliding. This snow-stopping unit is typically installed 50-100 cm from the edge of the roof.

The heating cable is installed in cable loops which are placed from the edge of the roof and 50-100 cm up the roof towards the snow-stopping unit. It is important that the cable is installed in cable loops up and down the roof and not as a straight line along the roof.
The cable must be secured at suitable intervals as the installation is exposed to harsh weather conditions.

In some cases the cable may also be covered by shielding sheets in the same metal material as that of the main roofing. This protects the cable from mechanical damage, direct sunrays, and fallen leaves, seeds etc.

Example
The following example is intended for a cold roof. The roof is 8 m long and the cable is installed in loops from the edge and 0,5 m up the roof. The installed rating on the roof must be 250 W/m².

1) Calculation of installation area: The installation area is:

8 m x 0.5 m = 4 m²

2) Calculation of total required output:

4 m² x 250 W/m² = 1000 W

3) Choice of products: in this example the installation can be carried out with a deviflex™ DTIP-18, 1075 W, 59 m and a devireg™ 316 with an outdoor sensor.

4) Calculation of C-C distance: The C-C distance between the cable loops is:

$$\text{C-C} = \frac{4\ \text{m}^2 \times 100\ \text{cm/m}}{59\ \text{m}} = 6.8\ \text{cm}$$

2.4 Product choice

The product choice depends on the area of use and the output. For an overview, please refer to the table bellow.

Area of use	Choice of rating		Product choice		
	Normal	Maximum	deviflex™ min. 17W/m	devimat™ 300	devi-iceguard™
Car parks	200-300 W/m²	300 W/m²	X	X	
Driveways	200-300 W/m²	300 W/m²	X	X	
Pavements	200-300 W/m²	300 W/m²	X	X	
Insulated:					
Steps	200-300 W/m²	300 W/m²	X		
Loading platforms	200-300 W/m²	300 W/m²	X	X	
Bridges	200-300 W/m²	300 W/m²	X	X	
Non-insulated:					
Steps	300-375 W/m²	400 W/m²	X		
Loading platforms	300-375 W/m²	400 W/m²	X	X	
Bridges	300-375 W/m²	400 W/m²	X	X	
Roof; tiles, metal	300-375 W/m²	350 W/m²	X		X
Roof; tar paper	150-300 W/m²	20 W/m cable	X		X
Cold roof					
Roof gutter/downpipe:					
Metal	30-40 W/m	50 W/m	X		X
Plastic	30-40 W/m	40 W/m	X		X
Wood	30-40 W/m	40 W/m	X		X
Hot roof					
Roof gutter/downpipe:					
Metal	40-50 W/m	50 W/m	X		X
Plastic	40-50 W/m	40 W/m	X		X
Wood	40 W/m	40 W/m	X		X

Choice of devireg™ thermostat
DEVI has developed a variety of devireg™ electronic thermostats for controlling the outdoor applications to meet the various frost, ice and snow problems. Electronic thermostats regulate the temperature quickly and precisely, and by choosing the optimal thermostat both safety and financial benefits may be achieved.

The DEVI outdoor thermostat programme includes the following items: the devireg™ 316, the devireg™ 330, the devireg™ 610, and the devireg™ 850. Depending on your requirements and the situation of the installation, the type of ice and snow melting thermostat will vary.

In order to ensure economic running costs and exploit the optimal comfort of the ice and snow melting system we recommend that the devireg™ 850 be used. This is especially relevant for applications where the total output exceeds 6 kW.

Thanks to its intelligent, digital sensors the devireg™ 850 system works with an incredible accuracy enabling a reduction of the energy consumption to the lowest possible level without compromising safety.

3.1 General information

DEVI's pipe tracing systems consist of deviflex™ heating cables, devireg™ thermostats and installation accessories. The devireg™ thermostats with sensors ensure that optimal results are achieved with the least possible amount of energy.

DEVI's pipe tracing systems may be used for two main purposes:

1. Frost protection of pipes.
2. Maintenance of the required temperature in pipes.

Frost protection systems are installed where there is a need to prevent water and sanitary pipes from freezing and becoming ice-damaged.

Temperature maintenance systems ensure that hot water or fluid pipes maintain the required temperature.

DEVI's pipe tracing systems may be used on the inside and outside of pipes, for indoor and outdoor pipe networks as well as for pipes above and below the ground.

The advantages of the pipe tracing systems are:

- Ice-free pipes
- Constant flow in pipes
- Depth reduction for underground pipes
- No repair costs after a hard winter
- No hardening of fatty products in pipe systems
- Efficient hot water supply

3.2 Heating cables on pipes

Heating cables can be installed on pipes above and below the ground.

Installing the cable on outdoor pipes above the ground

Outdoor pipes above the ground are especially exposed to cold and consequently, good insulation is necessary.

There are several ways in which the cable may be attached to the pipe:

1. One or more cables are led in a straight line along the side of the pipe, see fig. 1+2.
2. The cable is attached to the pipe in waves, see fig. 3.
3. The cable is wrapped in a spiral around the pipe, see fig. 4+5.

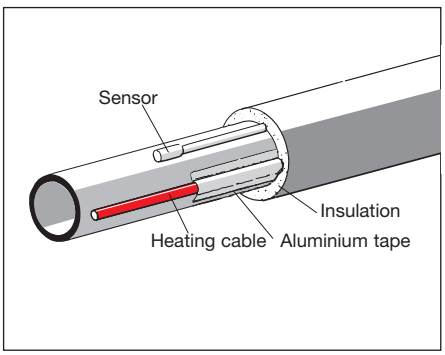


Fig. 1

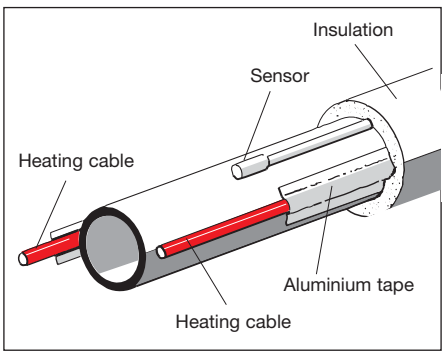


Fig. 2

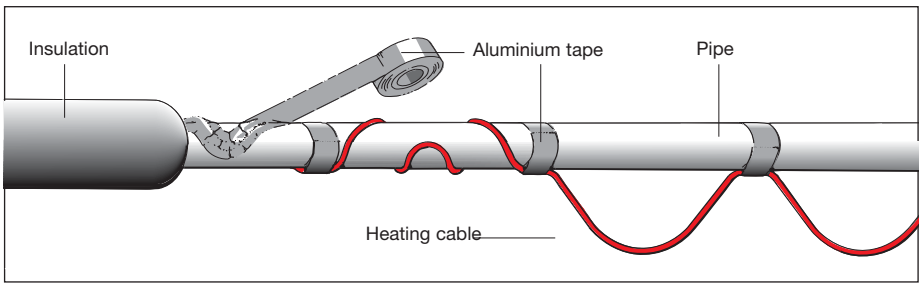


Fig. 3

Pipes are usually insulated with plastic foam, mineral wool or another kind of insulation, which can range in thickness, typically from 10-50 mm. The insulation should be protected against damp and moisture that could damage the insulation and reduce its efficiency.

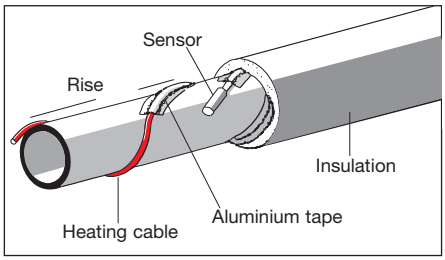


Fig. 4

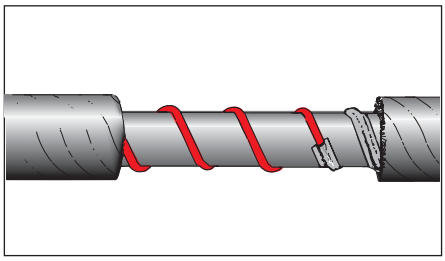


Fig. 5

If the cables are installed above the ground in a case, the case must be safe and solid. It should also be marked with a distinct warning sign, i.e.

"WARNING: 230 VOLT HEATING CABLES".

In most cases an output of 10 W/m is enough if:

- the outdoor pipe is not more than 50 mm in diameter,
- the insulation is not less than 50 mm,
- the outdoor temperature does not fall below -30°C.

Installing the cable on outdoor pipes below the ground
When pipes with frost protection systems are installed below ground level, they need not be buried as deeply as if there had not been any pipe tracing.

The heating cable is mounted directly on the pipe and secured with aluminium tape ensuring an optimal contact between the cable and the pipe.

All pipe trenches should be distinctly marked to indicate that electric heating cables have been installed on/in them. This can be done by laying a plastic tape (red, yellow etc.) over the area or on the outer pipe in which the cables are installed. It should also be marked with a distinct warning sign, i.e. " **WARNING: 230 VOLT HEATING CABLES".**

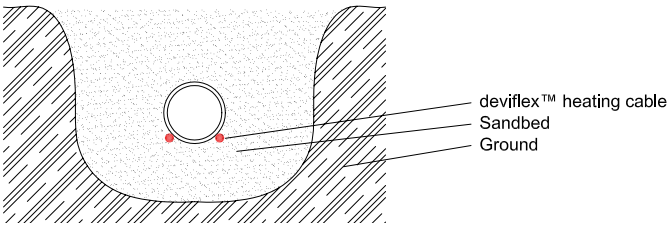
The following examples are designed to assist in the choice of frost protection systems and show some of the common installation possibilities.

Plastic pipe with heating cables installed in a larger plastic pipe
This installation method is often used in connection with under water pipes. It can protect the pipes to a certain extent against mechanical influences and help reduce the cooling output of the surrounding water.

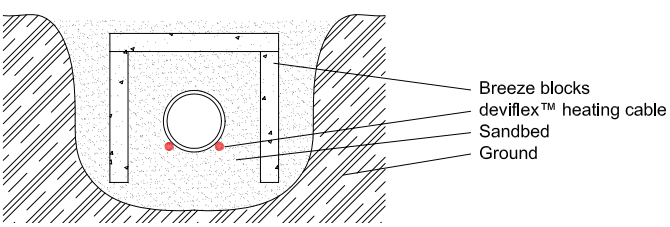
Pipe with heating cables installed in breeze blocks
Breeze blocks offer a solid protection for the pipes and the cables. The breeze blocks should be placed on a stable foundation of stones.

Pipe with heating cables installed for frost protection
The top of the pipe is placed at least 50 cm below ground level and protected by concrete tiles. The cable is surrounded by sand. A plastic tape (red, yellow etc) is laid on top of the concrete to indicate that heating cables are placed just below.

Pipe installed with heating cable

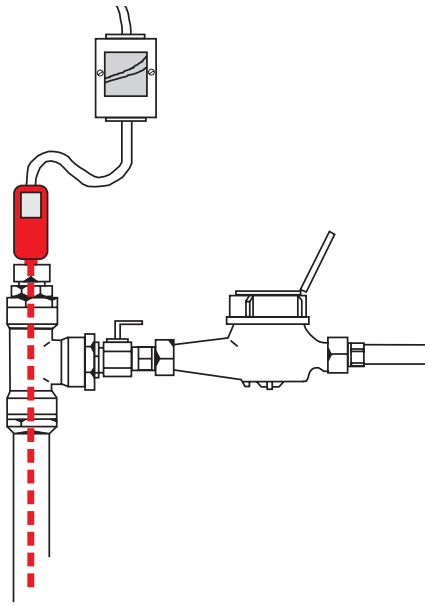


Pipe installed with heating cable in breeze blocks

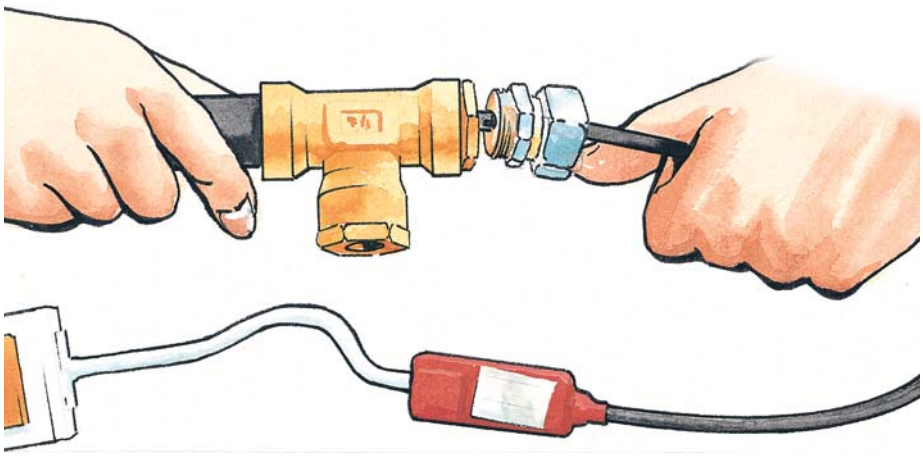


3.3 Heating cables inside pipes

It is appropriate to install the heating cable inside the pipe. For this installation method one can choose between the deviflex™



DTIV-9 (230 V, 9 W/m) and the devi-pipeheat™ 10. The method is very efficient as the cable gets into direct contact with the substance to be heated.



The deviflex™ DTIV-9 is designed to be installed inside pipes.

The heating cable is relatively stiff, which makes the installation easier. The polyethylene coating prevents any output or alteration in the taste of the drinking water.

This fact together with the fact that the heating cable is inside the pipe are great advantages for farmers and gardeners, who need a frost free water supply in their outdoor systems.

For this particular type of installation it is necessary to measure the required pipe run precisely as the cable cannot be cut or bent in a loop. The heating cable must not be led through valves.

Heating cables for drinking water pipes must be connected via a RCD relay. It should also be marked with a distinct warning sign, i.e. **“WARNING: 230 VOLT HEATING CABLES“.**

3.4 Self-limiting heating cables

DEVI’s self-limiting heating cables are used for ice and snow melting in roof gutters and downpipes, for frost protection of pipes, and for temperature maintenance of the hot-water supply.

Self-limiting heating cables are equipped with a temperature dependant resistant element between two parallel copper conductors. When the connecting conductors are connected to the mains, a current goes through the temperature dependant resistant element, which then starts heating. As the element is heated, the resistance value rises causing the current to decline and the heating is then reduced. This explains the self-limiting output.

This autonomous output regulation takes place on the entire cable according to the actual ambient temperature. If the ambient temperature rises, the heating output of the cable is reduced. Due to this self-limiting capability, overheating of the cable can be avoided, also if two heating cables are touching or crossing.

Due to the parallel power supply the heating cable can be shortened or extended anywhere. This simplifies the planning and installation.

The maximum output for the different installations and the operating outputs must be observed.

The bending diameter of the heating cables must not be less than 50 mm. The cable must only be bent on the flat side.

In order to limit the power consumption the heating cable should be switched off if it is longer than approx. 3 m, i.e. by using a devireg™ thermostat.

IMPORTANT!
DO NOT interconnect the two conductors of the self-limiting cable as this may cause a short circuit!

There are several different types of self-limiting cables:

1. The devi-iceguard™ is used for ice and snow melting in roof gutters and down pipes.
2. The devi-pipeguard™ is used for all types of cold pipes/installation for frost protection and to avoid the hardening of fatty products in the pipe system.
3. The devi-hotwatt™ is used in tracing systems to maintain the required temperature of hot water or other fluids in all hot pipes.

Specifications of the self-limiting cables

Cable	Colour	Application	Output	Dimension	Sheath
devi-iceguard™ 18	Black	Roof and gutter	18W/m at 0˚C*	6 x 12 mm	Polyolefin
devi-pipeguard™ 10	Blue	On pipes	10 W/m at 10˚C	6 x 12 mm	Polyolefin
devi-pipeguard™ 15	Black	On pipes	15 W/m at 10˚C	6 x 12 mm	Polyolefin
devi-pipeguard™ 25	Red	On pipes	25 W/m at 10˚C	6 x 12 mm	Polyolefin
devi-pipeheat™ 10	Blue	On/in pipes	10 W/m at 10˚C	6 x 8 mm	Helar
devi-hotwatt™ 55	Green	On pipes	8 W/m at 55˚C	6 x 12 mm	Polyolefin

*Output in ice approx. 30 W/m
Voltage 230 V AC
Max. temperature ON = 65˚C, max. temperature (accumulative) OFF = 85˚C
However, for devi-hotwatt™ 55 ON = 80°C, max. temperature (accumulative over 1000 hours) = 100°C

The considerations and calculations which should be made before installing a tracing system consisting of self-limiting cables are similar to those for deviflex™. Unlike deviflex™ cables, however, self-limiting cables can quite simply be cut or extended to the appropriate length.

The maximum lengths of self-limiting cables are presented in the table below.

Max. cable length at different ambient temperatures

	Blue (10 W/m)					Black (15/18 W/m)					Red (25 W/m)				
	Fuse*					Fuse*					Fuse*				
	10A	16A	20A	32A	40A	10A	16A	20A	32A	40A	10A	16A	20A	32A	40A
Ambient temperature	Max. heating cable length at 230 V														
	m	m	m	m		m	m	m	m	m	m	m	m	m	m
-20˚C	87	133	167			64	87	109	160		51	53	66	105	
-10˚C	102	143	186			71	100	125	160		57	59	74	118	
0˚C	116	167	208			83	111	139			66	67	83	133	
+10˚C	125	205				96	133	167			77	80	100	160	

*Fuses with C-characteristic

The stated maximum lengths for self-limiting heating cables are determined not only by the power consumption of the cable under normal circumstances but also – and mainly – by the power consumption during start-up, which can be up to 1.8-2.3 times as high.

3.5 Silicone heating cables

Thanks to their silicone insulation the silicone heating cables are very flexible and can be used under very cold or very hot conditions.

The maximum allowed surface temperature for silicone cables is 170˚C. The maximum allowed rating for silicone cables is 40 W/m.

Silicone heating cables are used on pipes where a high temperature (over 40˚C) or a high output (up to 40 W/m) is needed.

Silicone heating cables are installed in the same way as deviflex™ or devi-iceguard™ heating cables.

Silicone heating cables must not get into contact with oils or animal fat.

Silicone cables must be controlled by devireg™ thermostats. Depending on the application, the thermostats which can provide exactly the right control and regulation are the devireg™ 330's with a temperature range from -10 …+10˚C to +60…+160˚C.

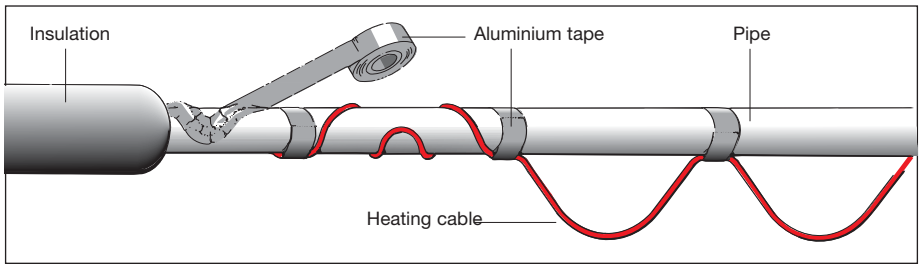
3.6 Installation

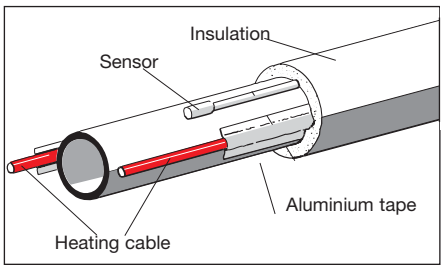
Calculation of cable length

In most cases frost protection for pipes requires an output of 10 W/m if the pipe has a diameter of less than 50 mm and the insulation is not less than 50 mm.

If this is the case a deviflex™ with a max. output of 10 W/m is an appropriate choice for cables installed on the outside of the pipe and a deviflex™ DTIV-9 for cables installed inside.

In order to find the appropriate length of deviflex™ cable to be installed per metre pipe, the required output per metre pipe is divided by the cable output per metre.





Example 1

If the required output is 10 W/m and the cable is a DTIP-8, the installed cable length per meter pipe is:

$$\frac{10\ \text{W/m}}{8\ \text{W/m}} = 1.25\ \text{m}$$

Example 2

If the required output is 15 W/m and the cable is a DTIP-10, the installed cable length per meter pipe is:

$$\frac{15\ \text{W/m}}{10\ \text{W/m}} = 1.5\ \text{m}$$

When the length is calculated for devi-iceguard™ or devi-hotwatt™, the following things have to be considered:

- Length of heated pipe
- Number of connections, specials, multiplied with 0.3 m heating cable
- Heating cable length for flanges, fittings
- Measured pipe extensions

The sum of the measurements will give the needed length of the devi-iceguard™ or devi-hotwatt™ heating cable.

Calculation of C-C distance

The table is a guide in finding the approximate C-C distance after the needed length of the cable per 1 m pipe has been calculated.

Outside pipe dimension (mm)	Inside pipe dimension (mm)	Inside pipe dimension (“)	C-C distance (mm) m of cable per m of pipe				
			1.1	1.2	1.3	1.4	1.5
34	25	1	250	170	140	110	100
42	32	1¼	310	210	170	140	130
48	40	1½	350	240	190	160	140
60	50	2	430	300	240	200	180
76	65	2½	520	360	290	240	210
89	80	3	630	430	350	290	260
102	90	3½	720	490	390	330	290
114	100	4	800	560	440	370	330
141	125	5	990	680	550	460	400
168	150	6	1180	810	650	550	480
219	200	8	1520	1050	840	710	620

General guidelines
Before installing the heating cables it is important to check the pipe for any signs of damage or leakage.

Besides, the pipes should be insulated as this reduces the heat loss from the pipe considerably. This goes for all pipes whether they are below or above the ground.

The cable should be attached to the pipe gently so it does not get damaged. The entire length of the cable should be attached to the pipe with aluminium tape and NOT plastic tape.

The cable should not be laid on the sharp edges of the pipe. Treading on the cables should be avoided and the cables should be treated carefully at all times.

All pipe trenches should be distinctly marked to indicate that heating cables have been installed on/in them. It should also be marked with a distinct warning sign, i.e. **"WARNING: 230 VOLT HEATING CABLES".**

When heating cables are installed below the ground, a plastic tape (red, yellow etc) is laid on top of the pipes/installation to indicate that cables are placed just below. Insulated pipes must be marked with a warning sign placed on the outside of the insulation material.

If the pipes with cables are installed in a case above the ground, the case must be safe and solid. It should also be marked with a distinct warning sign.

The screen of the heating cables must be earthed in accordance with the local electricity laws.

If the cable becomes stiff and difficult to bend due to the cold, it can be rolled out and connected to the mains for a short period, until it becomes flexible again. The cable must always be rolled out during this process.

The cables should not be installed at temperatures less than -5°C.

The resistance and the insulating resistance of the heating cable must be checked after installation. The resistance value must be as indicated on the label of the connection box.

The cable is attached to the pipe with strips of aluminium tape placed at intervals of approx. 25-30 cm. When the heating cable has been attached to the pipe, the entire length of the heating cable must be covered with lanes of aluminium tape. This prevents the heating cable from getting into direct contact with the insulation material and ensures a tight fit between the pipe surface and the heating cable.

Before the heating cable is attached to the plastic pipe, a full lane of aluminium tape should be applied to the pipe for the cable to lie on. This ensures a better heat distribution to the pipe. Cables should be attached at the lower part of the pipe or/and symmetrically around the pipe.

The connection box between the heating cable and the cold tail should also be fixed with aluminium tape. The sensor cable is attached to the pipe in the same way as the heating cable. The red tip at the end of the sensor should be covered with aluminium tape and be positioned centrally between the cable lines and on top of the pipe, if possible.

The bending diameter of the cable must not be less than 6 times the cable diameter.

The cable must not be subject to stress greater than 25 kg.

The deviflex™ cable must be evenly spread and the crossing of cables must be avoided.

3.7 Product choice

The deviflex™ with a max. output of 10W/m and the devi-pipeguard™ 10/15/25 heating cables are suitable for frost protection systems on pipes in applications where the temperature of the pipe does not exceed 40°C.

For frost protection of plastic pipes the output of the cable should not exceed 10 W/m. For metal pipes the output may be higher.

The deviflex™ DTIV-9 and the devi-pipeheat™ DPH-10 are used inside drinking water pipes.

The devi-hotwatt™ 55 is used in tracing systems to maintain the required temperature of hot water or other fluids in hot pipes (up to 85°C).

Silicone cables are used in tracing systems where a high temperature (up to 170°C) or a high output (up to 40 W/m) is needed.

DEVI's frost protection and temperature maintenance systems should be controlled by devireg™ 316, devireg™ 330 or devireg™ 610 thermostats. All devireg™ thermostats are equipped with a relay and are able to control an external contactor.

3.8 Heat loss calculation

To calculate the heat loss the formula or table below may be useful.

The formula below is not an exactly documented heat loss calculation and therefore, it should only be used as a guide.

The pipe dimension, the insulation thickness, and the ambient temperature are decisive for the dimensional output.

To calculate the heat loss for a pipe with a given insulation this simplified formula can be used as a guide:

Heat loss:

$$Q\ [W] = \frac{2 \times \pi \times \lambda \times l \times (t_r - t_u)}{\ln\ D/d} \times 1{,}3$$

Where

D [m]	=	Outer diameter, insulation
d [m]	=	Outer diameter of the pipe
π	=	Pi (3,14)
l [m]	=	Pipe length
t_r [°C]	=	Temperature of the liquid inside the pipe
t_u [°C]	=	Ambient temperature
λ [W/m°C]	=	Thermal conductivity for insulating material
1,3	=	Safety factor

λ - value for the insulation material (mineral wool and styrophor) – typically 0.04 W/m°C.

Below a logarithmic table is presented showing the lnX value.

(X = D/d)

Example

A 1" outdoor water pipe with an insulation of 30 mm is to be frost protected with heating cables. For outdoor installations a Δt of minimum 30° C is required. The pipe is 15 m long.

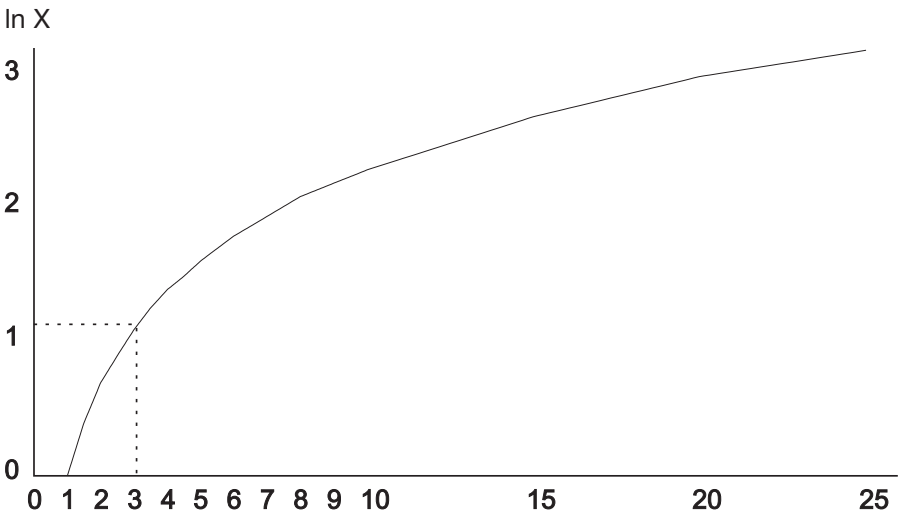
The heat loss is calculated in the following way:

D = 86 mm
d = 26 mm
l = 16 m
t_r = 0 °C
t_u = -30°C
λ = 0.04 W/m°C

$$Q = \frac{2 \times \pi \times 0.04\ W/m°C \times 15\ m \times 30\ °C \times 1.3}{\ln\ (0.086m/0.026m)} = 123\ W$$

In this example a 15 m deviflex™ DTIV-9 cable with an output of 135 W is chosen.

X	lnX
1.0	0.0
1.5	0.4
2.0	0.7
2.5	0.9
3.0	1.1
3.5	1.3
4.0	1.4
4.5	1.5
5.0	1.6
6.0	1.8
7.0	2.0
8.0	2.1
9.0	2.2
10.0	2.3
15.0	2.7
20.0	3.0
25.0	3.2



The table below shows the heat loss for various pipe dimensions, insulation thicknesses and temperatures.

λ - value for the insulation material (e.g. mineral wool) for this table is 0.04.

Inside pipe dimension Insulation thickness	" mm ΔT °C	½ 15	¾ 20	1 25	1¼ 32	1½ 40	2 50	2½ 65	3 80	4 100	6 150	8 200	10 250	12 300	14 350	16 400	18 450	20 500	24 600
10 mm	20	7.2	8.4	10.0	12.0	13.4	16.2	19.0	23	29	41	52	64	74	81	92	103	115	137
	30	10.7	12.6	15.0	18.0	20.2	24.4	29.0	34	43	61	78	95	111	121	138	155	172	205
	40	14.3	16.8	20.0	24.0	26.8	32.5	38.0	45	57	81	104	127	148	162	184	207	229	274
	60	21.5	25.2	30.0	36.0	40.2	48.7	58.0	68	86	122	156	191	222	243	276	310	343	411
	80	28.6	33.7	40.0	48.1	53.6	65.0	77.0	90	114	163	208	255	295	323	368	413	458	548
	100	36.0	42.4	50.3	60.5	67.4	81.7	97.0	114	144	205	261	320	372	407	463	520	576	689
	120	44.5	52.3	62.2	74.8	83.4	101.0	119.0	140	177	253	322	395	459	502	572	641	711	850
20 mm	20	4,6	5.3	6.1	7.2	7.9	9.4	11.0	13	16	22	29	34	40	44	50	56	61	73
	30	6,8	7.9	9.1	10.8	11.9	14.2	16.0	19	24	33	42	51	60	66	75	83	92	110
	40	9,1	10.6	12.2	14.4	15.8	18.8	22.0	25	32	44	56	68	80	88	99	111	123	147
	60	13,6	15.7	18.2	21.6	23.9	28.2	33.0	38	48	67	84	103	120	131	149	167	184	220
	80	18,2	21.0	24.4	28.8	31.8	37.7	44.0	51	63	89	113	137	160	175	199	222	246	293
	100	23,0	26.4	30.7	36.2	40.0	47.4	55.0	64	80	112	142	172	202	220	250	280	310	369
	120	28,4	32.8	37.9	44.9	49.4	58.7	68.0	79	99	138	175	212	249	272	309	346	383	456
30 mm	20	3.6	4.1	4.7	5.5	6.0	7.0	8.0	9	11	16	20	24	28	31	34	38	43	51
	30	5.4	6.1	7.1	8.2	9.0	10.6	12.0	14	17	24	30	36	42	46	52	58	64	76
	40	7.3	8.3	9.5	10.9	12.0	14.0	16.0	19	23	31	40	48	56	61	69	77	85	101
	60	10.9	12.4	14.2	16.4	18.0	21.0	24.0	28	34	47	59	72	84	91	103	116	128	152
	80	14.5	16.4	18.8	21.8	24.0	28.0	32.0	37	46	63	79	96	112	122	138	154	170	202
	100	18.2	20.8	23.8	27.6	30.1	35.3	41.0	47	57	79	100	121	141	153	174	194	214	254
	120	22.7	25.7	29.4	34.1	37.3	43.6	50.0	58	71	98	123	149	174	190	215	240	265	315
40 mm	20	3.1	3.5	4.0	4.6	4.9	5.8	7.0	8	9	12	16	19	22	24	27	29	33	39
	30	4.7	5.3	6.0	6.8	7.4	8.6	10.0	11	14	19	23	28	33	35	40	44	49	58
	40	6.2	7.1	7.9	9.1	10.0	11.5	13.0	15	18	25	31	37	43	47	53	59	66	78
	60	9.4	10.6	12.0	13.7	14.9	17.3	20.0	22	27	37	46	56	65	71	80	89	98	117
	80	12.5	14.0	16.0	18.2	19.9	23.0	26.0	30	37	50	62	75	87	94	107	119	131	155
	100	15.7	17.6	20.0	23.0	25.1	28.9	33.0	38	46	63	78	94	109	119	134	150	165	196
	120	19.6	22.0	24.8	28.4	31.0	35.9	41.0	47	57	72	96	116	135	147	166	185	204	242
50 mm	20	2.8	3.1	3.5	4.0	4.3	5.0	6.0	7	8	10	13	16	18	19	22	24	27	32
	30	4.2	4.7	5.3	6.0	6.5	7.4	9.0	10	12	16	19	23	27	29	33	37	40	48
	40	5.6	6.2	7.1	8.0	8.6	10.0	11.0	13	16	21	26	31	36	39	44	49	66	78
	60	8.4	9.4	10.6	12.0	13.8	15.0	17.0	19	23	31	39	46	54	58	66	73	80	95
	80	11.3	12.5	14.0	16.1	17.4	19.9	23.0	26	31	42	51	62	72	78	88	97	107	127
	100	14.2	15.7	17.8	20.2	21.8	25.1	28.0	32	39	52	65	78	90	98	110	123	135	160
	120	17.5	19.6	22.0	25.0	27.0	31.1	35.0	40	48	65	80	96	112	121	136	152	167	198
75 mm	20	2.4	2.6	2.9	3.2	3.5	3.9	5.0	6	7	8	9	11	13	14	15	17	19	22
	30	3.5	3.8	4.3	4.8	5.2	5.9	6.0	7	9	11	14	17	19	21	23	26	28	33
	40	4.7	5.2	5.8	6.5	7.0	7.8	9.0	10	12	15	19	22	26	28	31	34	38	44
	60	7.1	7.8	8.6	9.7	10.4	11.8	13.0	15	17	23	28	33	38	41	46	51	56	66
	80	9.4	10.3	11.5	12.9	13.8	15.6	18.0	20	23	30	37	44	51	55	62	68	75	88
	100	11.9	13.1	14.5	16.2	17.4	19.7	22.0	25	29	38	47	56	64	69	78	88	94	111
	120	14.6	16.1	17.9	20.0	21.6	24.4	27.0	31	36	48	58	68	80	86	96	107	117	137
	130	16.1	17.8	19.7	22.1	23.8	26.8	30.0	34	40	52	64	76	87	95	106	117	129	151
100 mm	20	2.0	2.3	2.5	2.8	3.0	3.4	4.0	5	6	7	8	9	10	11	12	13	15	17
	30	3.1	3.5	3.7	4.2	4.4	4.8	5.0	6	7	9	11	13	15	16	18	20	22	26
	40	4.2	4.6	5.0	5.6	6.0	6.7	7.0	8	10	12	15	18	20	23	24	27	29	34
	60	6.2	6.8	7.6	8.4	9.0	10.1	11.0	12	15	19	23	27	30	33	36	40	44	51
	80	8.4	9.1	10.1	11.2	12.0	13.4	15.0	16	19	25	30	35	41	44	49	54	59	69
	100	10.5	11.5	12.7	14.2	15.0	16.8	19.0	21	24	31	38	45	51	55	61	68	74	86
	120	13.1	14.3	15.7	17.5	18.6	20.9	23.0	26	30	39	47	55	63	68	76	84	91	107
	130	14.4	15.7	17.3	19.2	20.5	22.9	25.0	28	33	43	51	61	69	75	83	92	101	118
150 mm	20	1.8	1.9	2.1	2.4	2.5	2.8	3.0	4	5	6	7	8	9	10	11	12	13	14
	30	2.8	2.9	3.2	3.5	3.7	4.1	4.5	5	6	7	9	10	11	12	13	15	16	18
	40	3.6	4.0	4.3	4.7	4.9	5.5	6.0	7	8	10	11	13	15	16	18	19	21	24
	60	5.4	5.9	6.4	7.1	7.4	8.3	9.0	10	11	14	17	20	22	24	27	29	32	37
	80	7.2	7.8	8.5	9.4	10.0	11.0	12.0	13	15	19	23	26	30	32	35	39	42	49
	100	7.9	8.3	9.1	10.4	12.3	13.0	15.0	17	21	28	32	37	42	45	50	54	59	68
	120	11.3	12.3	13.3	14.6	15.5	17.0	19.0	21	24	30	35	41	46	50	55	60	66	76
	130	12.4	13.4	14.6	16.1	17.0	18.8	21.0	23	26	33	39	45	51	55	61	66	72	84

4.1 Floors

In cold stores where the temperature constantly lies between –20 and –30°C, cold will still be released to the surroundings even though the floor is well-insulated. This means that the materials which are in contact with the ground/soil, such as foundation and floor areas, will absorb the cold and leave the ground/soil to freeze. The water content in the ground/soil will expand and this can cause considerable damages due to frost erosion.

The same problem also appears in ice stadiums, which are artificially frozen. This can be avoided with DEVI's frost protection system, though.

Installed output

A typical value for frost protection installations is 15-20 W/m² and never less than 15 W/m². The max. C-C distance is 50 cm.

The downward energy loss depends on the U-value of the floor construction, the desired ground/soil temperature, and the temperature in the cold store. This can be calculated by means of the formula below:

$P\ (W/m^2) = \Delta t \times U$

Δt = temperature difference between ground/soil and temperature in the cold store

U = transmission coefficient of the floor in W/m² °C

Example

A cold store has the following parameters:

Indoor temperature:	-28°C
Ground temperature:	+5°C
U-value of the floor construction:	0.1 W/m² °C

Calculation of output per square meter:

P(W) = 33°C x 0.1 W/m² °C = 3.3 W/m²

Installation

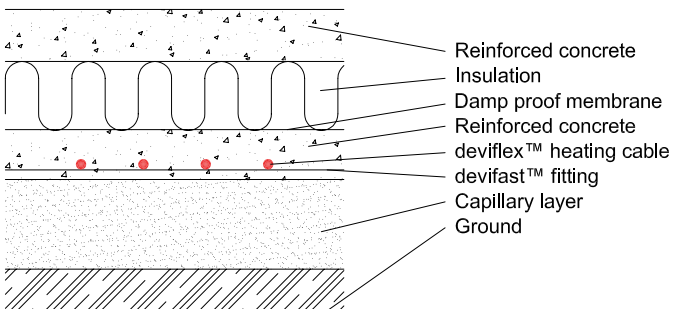
The installation of deviflex™ heating cables for frost protection purposes is performed in the same way as for ordinary concrete floor constructions.

For safety reasons two identical parallel circuits should be installed with two thermostats.

The heating cable should be placed under the floor insulation as the area below the insulated floor is the one to be frost protected. The cables should be placed directly on top of the hardened concrete only separated from the floor by means of a damp-proof membrane. The cables should be installed at least 5 cm below the insulation.

If there are any central elements in the cold store, the output must be higher in the foundation around these elements as the downward heat loss is particularly high through non-insulated concrete and steel constructions.

Floor in cold store



Product choice

A possible choice is the deviflex™ 20 W/m, 400 V connected to 230 V, which gives an output of approx. 7 W/m.

For an installation with a C-C distance of 40 cm this will give an installed output of approx. 17 W/m².

The control unit for permafrost protection applications is the devireg™ 330 (-10° to +10°C), where two circuits are connected to two separate thermostats.

Circuit 1 is set to +5°C and will ensure the required frost protection of the concrete.

Circuit 2 is set to +3°C and is connected to an 'alarm'.

If there are any defects on circuit 1, circuit 2 is activated, issuing a warning indicating that the 'reserve circuit' has been activated.

In large rooms it might be a good idea to divide the room into zones with two separate circuits and thermostats in each zone. For example a 300 m² room may be divided into three zones with two cables and two thermostats in each zone.

The wire sensors for the thermostats must always be placed in a protection pipe so the sensor can easily be replaced in case of defects.

4.2 Doors and gates

In cold stores there is a constant frost influence, which means that the door can easily freeze at the weather strippings when it is opened. Apart from the obvious damages to the door/weather strippings, frozen weather strippings may also prevent the door from shutting tight which again leads to an increased energy consumption in the cold room due to the large temperature differences.

It is therefore recommended to use silicone cables to heat the weather strippings in such doorways.

In connection with sliding doors and swing doors, etc. the frost problems may also concern the slide bars. This does not only apply to cold stores but also to gates and doors of car washes, etc. where there is a potential frost risk during winter. Here, the potential problems may also be solved by means of deviflex™ heating cables.

Typically, frost protection systems are used for sliding doors, swing doors, gates in car washes, doors in cold stores, edges of rollers in water treatment plants etc.

Installed output
The installed output for the gates and doors of cold rooms is typically 12-15 W/m for each weather stripping.

For swing doors and slide bars of outside gates the installed output must correspond to the output used for ice and snow melting systems, i.e. typically 250-350 W/m^2.

Example 1
An automatic sliding gate to a cold room is to be protected against frost. The door is 4 m high and 5 m wide.

A silicone cable is attached to the back of the weather stripping before the weather stripping is secured. A 13 m cable with an output of approx. 180 W (14 W/m) is used.

Example 2
For an outside sliding gate the slide bar in the floor is to be frost protected with a deviflex™ heating cable. The bar is 8 m long and 0,1 m wide.

This gives an area of 0.8 m^2 where an output of approx. 240 W (300 W/m^2), i.e. approx. 30 W/m sliding bar, must be installed. Therefore, a deviflex™ DTIP-18, 270 W, 15 m can be laid forwards and backwards along the sliding bar.

Installation
The installation on weather strippings around gates and doors, etc is done by attaching a silicone cable with aluminium tape to the back of the weather stripping before the weather stripping is secured.

For the purpose of frost protecting slide bars in floors the cable must be placed in the concrete directly under the slide bar. It is important to that the cable is placed in such a way that it cannot be damaged during the later installation of the bar.

Product choice
As silicone cables are very flexible and have a small diameter, they can easily be attached to the weather stripping. Furthermore, silicone cables are available pre-prepared in any length and can be adapted to any individual task.

The deviflex™ heating cables with an output of 17-20W/m are suitable for embedment in concrete, i.e. in connection with slide bars and swing doors.

In connection with gates in cold stores the heating cable is usually turned on permanently.

For other applications an electronic thermostat with a wire sensor, e.g. the devireg™ 330 or 610 is recommended.

In connection with weather strippings the wire sensor must be attached to the weather stripping near the heating cable with self-adhesive aluminium tape.
In connection with slide bars a pipe with the wire sensor is embedded in concrete as close as possible to the bar in which the wire sensor is placed.

4.3 Drains

In connection with ramps, low terrain, etc. a drain system of rain and melt water is often established. Geographical conditions with changing temperatures at freezing point can make the drain systems freeze, causing significant ice formations. During periods of thaw the drain system cannot always thaw completely and therefore, the melt water is not drained away before the frost sets in again. This leads to new problems when the melted water refreezes.

These problems can be avoided by installing deviflex™ heating cables in drainpipes and gratings, etc.

Installed output
The typical output for frost protection and ice melting is 200-300W/m² depending on the local climate conditions.

In most ordinary types of drain gratings and pipes the output is approx. 30-50 W/m pipe.

Example
A steep ramp leading down to a garage ends directly in front of the gate. To avoid that rain and melt water damages the gate or enters the garage a drain grating has been established directly in front of the gate. This grating must be frost protected.

The gate is 3 m wide and the grating channel measures 0,1 x 0,1 m. At the bottom of the channel, which continues to the frost-free depth (approx. 1 m), a heating cable is placed. The installed heating cable must therefore have an output of approx. 120 Watt, covering approx. 4 m of grating channel.

A deviflex™ DTIP-18, 134 W, 7 m placed double in the channel will be sufficient to lead the melt water away.

Installation
To ensure adherence the deviflex™ heating cables can be attached to drain gratings and drain pipes by means of devifast™ fitting bands or spacing clips with a distance of approx. 30 cm. This will also ensure a suitable distance between the cables.

Product choice
The deviflex™ electrical heating cables with an output of 17-20 W/m and the devireg™ thermostats 316, 330, or 610 may be used for frost protection of drain gratings and drain pipes. The devireg™ thermostats ensure that heat is only switched on when needed.

Two thermostats can be connected in series so the system automatically switches off when the temperature reaches a certain level and there is no longer any risk of icing.

4.4 Antennas and wires

DEVI's heating systems can be used in connection with frost protection of masts, parabolic antennas, etc. where there is a big risk that ice (icicles) and snow may drop on pedestrians. At the same time, it is no longer necessary to remove ice and snow manually.

Installed output
Typically, heating cables with an output of 17-20 W/m are used. As the main purpose of the system is to melt beginning ice formations at freezing point, the typical installed output is approx. 200-300 W/m².

As the output per m² depends on the construction to be frost protected, it is difficult to give any general guideline. A C-C distance of 5-10 cm will typically be suitable.

Installation
The attachment of electrical heating cables to masts, wires, antennas, etc. depends on the individual task but often the cables can be attached with devifast™ aluminium tape or be winded around the element in question.

Product choice
The deviflex™ heating cable with an output of 17-20 W/m can be used to frost protect antennas and wires. A devireg™ 330 thermostat is recommended.

4.5 Tank systems

It may be necessary to frost protect pipes and tanks to ensure a free passage but it may also be necessary to maintain a certain minimum temperature in tank systems to avoid problems with stiff scraps, coagulation or frost damages in the tank.

Frost protection systems may be used for various tanks and containers within the agricultural and industrial sectors.

Installed output
Even if the tank is insulated, the heat loss through the insulation has to be compensated if there is a need to maintain a certain temperature. This may be done by attaching heating cables to the pipes and tanks.

There are some preconditions for calculating the required output in containers or tanks:

- The tank has to be insulated all over the surface.
- The formula should be used only to maintain and not to increase temperatures.

Required data:

t_1 [°C]:	Temperature of the liquid in the tank
t_2 [°C]:	Ambient temperature
$\Delta t = t_1 - t_2$ [°C]:	Difference between liquid and outdoor temperature
A [m²]	Total surface area of the tank
d [m]	Insulation thickness
λ [W/m °C]	Thermal conductivity of the insulation
1.3	Safety factor

If the thermal conductivity is not known, λ = 0.04 W/m² °C may be used.

Formulas:

Transmission coefficient (U):

$U = \lambda/d$ [W/m² °C]

Heat loss:

$\phi = U \times A \times \Delta t \times 1{,}3$ [W]

Calculation example:

t_1 = +20°C
t_2 = -20°C
$\Delta t = t_1 - t_2$ = 20°C - (-20°C) = 40°C
A = 10 m²
d = 0.1 m
λ = 0.04 W/m°C

$U = \lambda /d$ = 0.04 W/m°C /0.1 m = 0.4 W/m² x °C

ϕ = U x A x Δt x 1.2 = 0.4 W/m² °C x 10 m² x 40 °C x 1.3 = 208 W

Installation
The heating cable should be placed evenly on the entire tank surface. If this is impossible, the heating cable should be installed on the lower part of the tank.

Product choice
The deviflex™ heating cables with an output of 17-20 W/m and the self-limiting heating cables can be used to frost protect tank systems.
The devireg™ 316, devireg™ 330 and devireg™ 610 can be used to frost protect tank systems.

4.6 Concrete hardening

DEVI's heating systems can be used to harden concrete during winter, when building activities cannot be postponed even though the temperatures drop below zero.

DEVI's heating systems can be used for all projects where a normal concrete hardening process has to be maintained.

Installed output
The required output is approx. 400 W/m³ if the temperature is -10°C or more. If the temperature falls below -10°C, the construction should be covered.

The output should not be higher than 400 W/m³ as this might increase the speed of the normal concrete hardening process, damaging the concrete and reducing the quality of the concrete construction.

Depending on the outdoor temperature the system can be maintained at approx. +1 to +2°C for a week. Then the output may be reduced gradually.

Example
A factory manufactures precast concrete elements for house building. As the casting of the elements takes place outdoors, it is necessary to frost protect the hardening process during winter.

Among several products the factory manufactures wall elements with a measure of 2,65 m x 1,6 m (h x w) and a thickness of 100 mm. This gives a total of 0.424 m² concrete per element.

To frost protect such an element a heating cable with the following output should be used: 0.424 m² x 400 W/m² ~ 170 W.

A deviflex™ DSIG-20, 170 W, 9 m, 230 V heating cable could be used.

The cable is attached to the reinforcement with a C-C distance of approx. 45 cm.

To control the temperature the heating cable is connected to a devireg™ 330 thermostat (-10°C to +10°C), with a sensor placed in the concrete between two cables. The thermostat is preset to maintain a temperature in the concrete of +2 to+3°C.

With an average ambient temperature of approx. -8°C and a hardening period of 7 days the power consumption will be no more than 10-20 kWh.

Installation
The deviflex™ heating cables are attached to the reinforcement net directly in the concrete construction (concrete slab, foundation, wall) by means of cable strips, etc.

If cable strips are used, it is important not to tighten these around the heating cable as it should be easy to move the cable through the strips.

The cables must not cross or touch each other. The bending diameter of the cable must not be less than 6 times the cable diameter and the cable must not get into contact with the insulation material.

Heating cables should be installed along the outer edge of the concrete slab that is in contact with the air (min. 5 cm below the surface).

Product choice
The deviflex™ cables with an output of 17-20 W/m and the devireg™ 330 (-10°C to +10°C) can be used for concrete hardening applications.

5.1 Heating of stables

In modern farming it is very important that the animals have the most optimal conditions. Piglets must not lose body heat to the surroundings or the floor in order to grow quickly. An optimal solution is to install deviflex™ heating cables in the floor of the stable or farrowing pen to ensure that the animals grow easily and obtain extra heat.

In farrowing pens the piglets must have a temperature of approx. 30°C for the first two days. The temperature must then be reduced gradually to approx. 18°C during the next 4 weeks. This is easily done by means of an electronic devireg™ thermostat controlling the heat regulation.

In chicken sheds it is also very advantageous to install floor heating with deviflex™ electrical heating cables. A more even temperature at the floor, without heating the entire building, will obviously reduce the energy consumption considerably.

Other advantages are a cleaner and drier environment for the chickens, which has proven to have a considerable influence on the well-being of the chickens, including their habit of pecking each other when in unsatisfactory environments. These are all factors which will reduce diseases, etc.

Furthermore, the fast drying of animal droppings will make floor cleaning easier and faster when changing between two broods of chickens.

DEVI's heating systems can be used for farrowing pens, chicken sheds, pig farms, other types of stables etc.

Installed output
The heat requirement in a stable depends on the floor, the necessary temperature in the stable, the insulation, the air humidity, and the number of animals.

The output requirement also depends on the size of the animals. The following output values are recommended:

Chickens	200 W/m²
Piglets below 20 kg	200 W/m²
Pigs from 20 to 50 kg	150 W/m²
Pigs above 50 kg	100 W/m²

Installation
The installation in stables is performed as an ordinary installation in concrete floors. To achieve the best output it is important that the stable floor is correctly insulated.

In farrowing pens it is possible to install a high output (150-200 W/m²) in the area where the piglets are kept and a relatively lower output in the rest of the stable.
Despite the harsh environment the system is maintenance-free and the floor may be both high pressure cleaned and disinfected.

Product choice
In stables deviflex™ cables with an output of 17-20 W/m can be installed. It is possible to connect several different types of devireg™ electronic thermostats to a wire sensor in the floor.

The devireg™ 330 is intended for DIN rail mounting and the devireg™ 610 is moist-proof (IP 44) and can be installed in moist environments.

It often proves suitable to install a thermostat in each farrowing pen or small group of farrowing pens so the temperature can be separately controlled in each pen.

5.2 Heating of seed beds

In order to speed up vegetation and reproduction in greenhouses the soil may be heated from early spring so the vegetation starts earlier and the harvest lasts longer. Besides, it facilitates the cultivation of heat-requiring plants which normally only grow in subtropical/tropical latitudes.

In order to reach the necessary temperatures deviflex™ heating cables are ideal and if they are equipped with electronic devireg™ thermostats and sensors, the energy consumption will be minimal.

Heating of seed beds can be used in greenhouses, cutting beds, seed beds and reproduction boxes.

Installed output
In order to obtain a sufficient temperature in the soil, an output of 75-100 W/m^2 should be used.
The output of the cable should not exceed 18 W/m, though, as there is a risk of drying the roots if the temperature is too high.

Installation
To prevent the heat from going downwards, it is necessary to use insulation sheets with a low water absorbing capacity (e.g. styrophor). The sheets must then be covered with 0.2 mm of PE foil to protect against soakage.

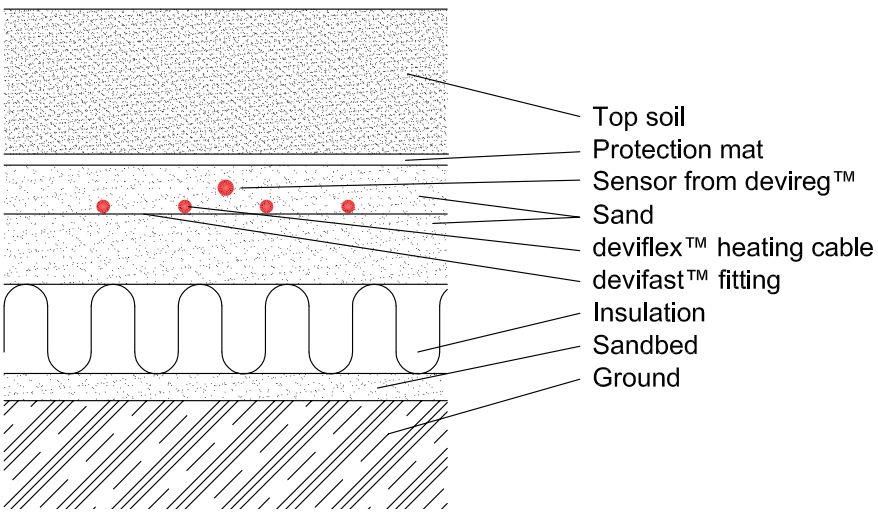
The foil should then be covered with 10 cm of sand (not gravel) , in which the heating cables should be placed so there is 5 cm of sand both under and above the cable. The distance between the cables must be approx. 15 cm. On top of the sand a net or mat should be placed to protect the cable against damages from spits and other tools.
Finally, the sand layer should be topped with soil or seed beds, pots, etc..

Product choice
The deviflex™ cables with an output of 17-20 W/m are the most commonly used heating cables for this application.

To control the temperature in the soil of greenhouses a devireg™ 330 or 610 should be used. The sensor should be placed in the soil.

The optimal soil temperature depends on the type of plants and their ages. In greenhouses the typical root temperature lies between 15 and 25˚C. In cutting beds and seed beds the temperature should be up to 30˚C.

Heating in green house



With deviflex™ heating cables installed in football fields or golf courses the soil can be heated and the growth of grass can start in the early spring. The area will then be ready up to two months earlier than usual.

Furthermore, the season can be prolonged in autumn when the period until the grass stops growing can be extended by means of heating the roots.

Installed output
The required output for soil heating is normally 50 -100 W/m² depending on the geographic location, the nature of the soil, and the relevant season.

In football fields with international measures (70 x 110 m) an output of 400-750 kW (50-100 W/m²) is typically installed.

Example 1
A football field of 70 m x 110 m is to be heated with deviflex™ heating cables.

An output of 90 W/m² is installed amounting to a total of 693 kW.

Example 2
On a golf course a number of greens with a total area of 975 m² are to be heated with deviflex™ heating cables.

An output of 80 W/m² is installed amounting to a total of 78 kW.

Installation
DEVI's deviflex™ heating cables can be installed both when the grass is laid and when the grass is renewed. The latter installation takes place by ploughing the heating cables directly into the ground.

The grass area must be level and have a good drainage.

The installation is performed with a special plough designed to hold 1-3 cable drums at a time and place them in the correct depth.
The distance between the cables naturally depends on the output per metre and the desired output per m², typically 20-40 cm. The area will not be damaged and will be completely ready for use 10-12 days after the installation.

The heating cables are installed 25-30 cm below the surface to avoid damages to the cables in connection with the use of e.g. javelins.

When the above output values are installed, the temperature in the root zone, approx. 10 cm below the surface, will be 6-10°C.

In order to keep the soil warm and moist the area should be covered with plastic or a similar material when it is not being used.

Product choice
The deviflex™ heating cables with an output of 17-20 W/m, 230/400 V can be used for applications in grass areas.

Besides, a devireg™ thermostat (the devireg™ 316 or devireg™ 330) should be used to measure the temperatures in the root zone, approx. 10 cm below the surface.

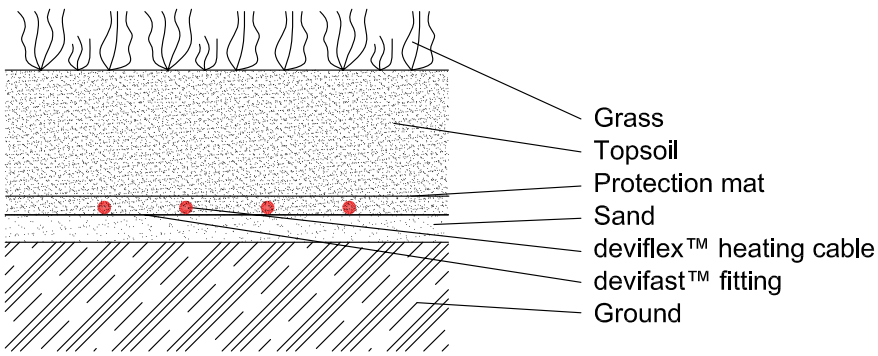
The heated area can be divided into a number of zones, each with a separate regulation unit.
For heating cable systems of this size, 400 V heating cables are often used.

When major stadiums are concerned the required output is often easily accessed. In such stadiums powerful lighting systems are normally installed which are only used when the field is used. It is rather uncomplicated to change such installations so the power access can be used for the cable installation when the lighting system is not used.

The heating cables should be switched on 4-6 weeks in the spring before the field can be used as the root net must have started growing before the field can be used without any risks of damaging the grass.

For safety reasons heating cables in grass areas should be screened and earthed with a RCD-relay.

Heating of grass areas



DEVI's heating systems can be used to heat all types of halls and large rooms such as industrial rooms, sports halls, conference rooms, etc.

The heating is achieved by DEVI's heating cables or mats installed in the floor and devitemp™ fan heaters or HeatLine™ electrical heating cassettes installed under the ceiling.

Depending on the type of room and the requirements for the heating system the above heating solutions can be used individually or as a combination.

Heating with deviflex™ electrical heating cables
The deviflex™ electrical heating cables are particularly well suited for rooms where a comfortable temperature near the floor is desirable, e.g. in sports halls, conference rooms, etc. Electrical heating cables should be combined with one of the other heating solutions if larger rooms are to be completely heated, though. This may be the case in packing areas of storage rooms.

Heating with HeatLine™ electrical heating cassettes
HeatLine™ is well suited as a local heat source for high-ceiling rooms and smaller areas within an open space. HeatLine™ can also be used to heat covered outdoor areas on cold days.

If it is necessary to heat small work-places/workshops in major store rooms or halls where the general temperature must be low or where it is not economical to heat the entire room , it is possible to heat certain areas locally by installing HeatLine™ electrical heating cassettes under the ceiling.

Electrical heating cassettes are not suited for ordinary low-ceiling rooms.

The HeatLine™ electrical heating cassettes for installation under ceilings are available with outputs from 600 W to 4200 W.

Heating with devitemp™ electrical fan heaters
The devitemp™ is designed for heavy operations in industrial rooms and may be used for both permanent and mobile applications. The devitemp™ has an excellent output for fast heating, does not require complicated installation, and may be used as an economical extra heat source in combination with deviflex™ heating cables and/or HeatLine™ electrical heating cassettes.

In buildings without a heating system it may be necessary to heat the rooms temporarily during winter to avoid frost damages etc. For this purpose devitemp™ fan heaters are ideal.

The devitemp™ fan heaters are available with outputs from 3 kW to 21 kW in the 400 V version and 3 kW in the 230 V version.

Installed output
In connection with the heating of halls and industrial rooms, etc. the installed output depends on a number of factors, such as the size of the room, the heat loss, the ventilation, the climate conditions, the desired temperature, and the required heating velocity.

The typical values are:

Area	Normal output	Max. output
Store room	60-100 W/m²	200 W/m²
Shop	60-100 W/m²	200 W/m²
Workshop	80-100 W/m²	200 W/m²
Sports hall	50-80 W/m²	
Conference room	80-120 W/m²	

Depending on the requirements of the installation the above heating elements can be used individually or as a combination as long as the total output corresponds to the actual heat requirement and the properties of the individual heating element.

To control the temperature in large rooms/halls it can often be an advantage to divide the heating system into a number of zones with separate temperature regulations. If possible the division should be limited according to the natural sectioning of the room.

Example 1
In a 1400 m² sports hall with a floor to ceiling height of 8 m, a total output of 98 kW is installed. 70 kW is used for the deviflex™ electrical heating cables in the floor (50 W/m² floor area) and 28 kW is used for the HeatLine™ electrical heating cassettes under the ceiling.

Example 2
In January, a heating system has not yet been installed in a newly built storage hall. To provide the workmen with satisfactory working conditions devitemp™ fan heaters are used to ensure a comfortable working temperature during the day.

The hall is 700 m³/3500 m² respectively and the heat loss is approx. 40 W/m². The night temperature is approx.–10°C.

By placing 3 devitemp™ 121T (21 kW), it is possible to raise the temperature from -10° to +15°C in less than two hours. The workmen can set the timer at the end of the day so the fan heaters will start 1-2 hours before they arrive the next day.

8.1 Ground thawing

Excavating and preparation of the ground can be a problem when the frost sets in during winter. With DEVI's electrical heating cables or mats these problems can be solved quickly and efficiently.

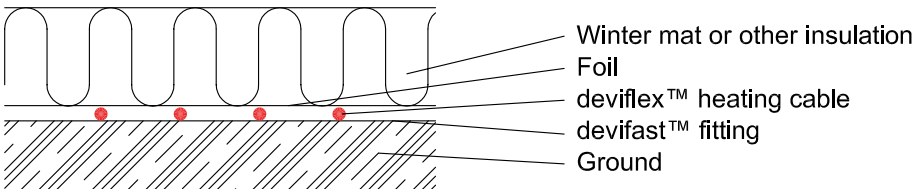
A temporary placing of heating cables covered by a winter mat/ insulation mat, for example during the night, can thaw the ground so it resembles a damp day in the spring.

The typical areas of use are construction sites, building areas, excavations, and churchyards.

Installed output
250-350 W/m² should be installed at temperatures from -5° to -10°C. At lower temperatures a higher output is recommended. For practical reasons the maximum output is 400 W/m² (DSIG-20, C-C distance 5 cm). Alternatively, the thawing period should be prolonged or/and a thicker layer of insulation should be used.

Example
Frost has set in, and for the last few weeks the night temperature has been approx. -10°C.
A hole of 1 x 2 x 2 m is to be dug in order to access an underground electrical junction box.

Ground thawing



The day before the hole is to be dug, 44 m of deviflex™ DTIP-18 heating cable is laid with a total output of 790 W. The cable is laid on devifast™ fitting bands with a C-C distance of 5 cm, providing an output of 360 W/m².
The cable is switched on overnight. The next day it is possible to dig in the ground like on an ordinary spring day. The power consumption for this solution is 10-15 kWh.

Installation
The deviflex™ electrical heating cable or mat is placed directly on the ground and covered with a foil coated winter mat (mineral wool) or the like. When the deviflex™ heating cable is laid, it should be fixed with devifast™ fitting band to ensure a correct C-C distance. Alternatively, a 300 W/m² devimat™ DSIA may be used.

Product choice
The deviflex™ heating cables with an output of 17-20 W/m or devimat™ 300 W/m² are chosen.
No regulation is necessary in connection with this type of application but the connection must be earthed for safety reasons.

8.2 Condensation protection of floors

In doorways between cold stores and heated rooms condensed water may form on the floor due to the constant shifts between cold and warm air caused by the opening and closing of doors. This can result in dangerous ice formations on the floor and therefore, the floor in these areas must be heated. As an extra comfort it will also limit the flow of cold air to the heated area.

Installed output
The installed output for condensation protection of floors is normally 250 W/m².

Installation
The deviflex™ or devimat™ is installed in the same way as in ordinary concrete floors but should be placed as close to the floor surface as possible without spoiling the structural integrity of the floor.

Heating cables/mats must be installed at both sides of the doorway but they should not be laid across expansion joints. This means that separate heating elements must be installed on the inside and outside of the doorway.

To solve the problem an output of approx. 250 W/m² on each side of the doorway is sufficient. The

system should cover an area of min. 1 metre from the door and 0,5 metre to each side.

The wire sensor of the thermostat must be placed between two cables and as close to the floor surface as possible. Wire sensors must always be placed in a protection pipe which is sealed at the end so they can easily be replaced.

Product choice
The deviflex™ with an output of 17-20 W/m and the devimat™ 300 are ideal products for these applications.

The devireg™ 330 (-10˚C to+10˚C) is chosen for this application. The temperature of the thermostat must be set to ensure that the floor surface is kept frost-free (approx. +2˚C).

8.3 Heating of thermal bridges

DEVI's heating systems can be used to avoid temperature differences in floors caused by thermal bridges.

DEVI's heating systems can also be used to avoid or limit draughts, e.g. at windows, doors, exterior walls, and central elements in concrete buildings.

Installed output
In connection with thermal bridges along walls an output of 15-30 W/m is installed, depending on the wall and floor construction. In connection with single-store buildings on ground it is often sufficient to install one cable length whereas two cable lengths are necessary in multi-store concrete buildings.

Example
In a concrete building where the horizontal division (200 mm) adjoins open air, a double deviflex™ DTIP-18 (36 W/m) is installed in the concrete layer directly under the exterior wall.

This protects against heat losses through the exposed concrete layer, prevents condensation, and helps avoid cold floors and draughts along the wall down to approx. -20˚C.

Installation
In connection with rim zone heating the heating cable must be installed approx. 20 mm below floor surface and must not be led more than 1 m into the floor.

Thermal bridges are installed exactly where the floor and the wall meet (on the inside) or directly under an exterior wall.

Product choice
In rim zones it is recommended to use a thermostat capable of limiting the temperature in the floor, e.g. a devireg™ 122, 522, 540, or 550. These combi-thermostats are equipped with a built-in room sensor, which registers the room temperature, and a wire sensor to be placed under the floor, which keeps the temperature in the floor within a preset maximum temperature.

For thermal bridges thermostats with wire sensors to be placed in a suitable position in the thermal bridge are used.

The deviflex™ with an output of 17-20 W/m can be used for applications in rim zones and thermal bridges.

9.1 C-C distance

The C-C distance is the distance between the cables.

In an average house the C-C distance should not exceed 15 cm if the cables are installed as part of a total heating system. If the C-C distance is higher, cold zones may form on the floor surface. The bigger the C-C distance is, the more concrete should be applied to the cables to ensure an even temperature on the floor surface.

When deviflex™ heating cables are installed, we recommend the use of devifast™ fitting bands. These bands are designed to ensure a C-C distance at regular intervals of 2.5 cm, e.g. 10 cm, 12.5 cm, 15 cm, 17.5 cm, etc.

Two different formulas may be used to calculate the C-C distance:

1)

$$\frac{\text{Sum of usable floor space [m}^2\text{] x 100 [cm/m]}}{\text{Cable length [m]}} = \text{C-C distance [cm]}$$

2)

$$\frac{\text{Output per m cable [W/m] x 100 [cm/m]}}{\text{Output per m}^2\text{ usable floor space [W/m}^2\text{]}} = \text{C-C distance [cm]}$$

Example 1
The deviflex™ DTIP-18, 535 W, 29 m is to be installed in a bathroom with a usable floor space of 3 m².

The calculated C-C distance is:

$$\frac{3\ \text{m}^2 \times 100\ \text{cm/m}}{29\ \text{m}} = 10.35\ \text{cm}$$

If we use devifast™ fitting bands, we can install the heating cable in this bathroom with a C-C distance of 10 cm.

Example 2
For a floor renovation we choose a deviflex™ DTIP-10 cable (10 W/m). If the calculated output is 120 W/m², the calculated C-C distance is:

$$\frac{10\ \text{W/m} \times 100\ \text{cm/m}}{120\ \text{W/m}^2} = 8.3\ \text{cm}$$

The table shows the C-C distances and corresponding outputs per m²:

C-C distance	20W/m cable	18 W/m cable	17 W/m cable	10 W/m cable
5 cm	400 W/m²	360 W/m²	340 W/m²	200 W/m²
7.5 cm	266 W/m²	240 W/m²	227 W/m²	133 W/m²
10 cm	200 W/m²	180 W/m²	170 W/m²	100 W/m²
12.5 cm	160 W/m²	144 W/m²	136 W/m²	80 W/m²
15 cm	133 W/m²	120 W/m²	113 W/m²	66 W/m²
17.5 cm	114 W/m²	103 W/m²	97 W/m²	57 W/m²
20 cm	100 W/m²	90 W/m²	85 W/m²	50 W/m²
22.5 cm	89 W/m²	80 W/m²	76 W/m²	
25 cm	80 W/m²	72 W/m²	68 W/m²	

9.2 The devifast™ fitting bands

If we want to calculate the length of a devifast™ fitting band, we first have to determine the distance between the fitting bands.

For concrete floors where the cable is covered with 3 cm of concrete or more and the C-C distance is more than 10 cm, the distance between the devifast™ fitting bands can be up to 1 m.

For thin floors where the cable is covered with 1-2 cm of self-levelling compound and the C-C distance is 10 cm or less, the max. distance between the devifast™ fitting bands is 25 cm.

Below is the formula for calculation of C-C distance.

$$\frac{\text{Sum of usable floor space [m}^2\text{] x 100 [cm/m]}}{\text{Distance between devifast™ [cm]}} + l_W \text{ [m]} = \text{length of devifast™ [m]}$$

l_W is the length of the wall parallel to which the devifast™ is installed.

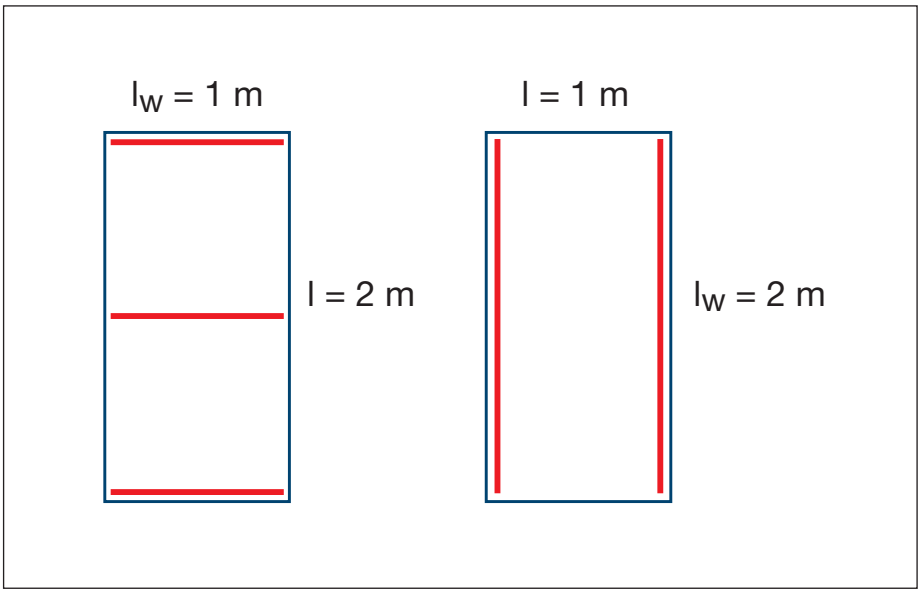
Example
The usable floor space is 1 m x 2 m = 2 m².

If we install devifast™ fitting bands parallel to a 1 m wall and the distance between the devifast™ fitting bands is 1 m, we need a fitting band with a length of:

$$\frac{2\ m^2 \times 100\ cm/m}{100\ cm} + 1\ m = 3\ m$$

If we install devifast™ fitting bands parallel to a 2 m wall and the distance between the devifast™ fitting bands is 1 m, we need a fitting band with a length of:

$$\frac{2\ m^2 \times 100\ cm/m}{100\ cm} + 2\ m = 4\ m$$



As we can see from this example, the length of a devifast™ fitting band may vary although the area and the distance between the devifast fitting bands remain the same

The installation of deviflex™ heating cables and devireg™ thermostats should comply with general and local regulations. The cables and the thermostats should only be connected by an authorised electrician.

It is important that the floor construction is well insulated according to the building standards so the downward heat loss is kept to a minimum.

Another important element is the vertical rim zone insulation, which should be efficient in order to prevent heat from being transported to the foundation walls or adjoining rooms.

The foundation must be clean and free of sharp objects.

The cables must never get into contact with the insulation material or become enveloped by it in any way.

The cables must be evenly spread on the available floor and led under permanently fixed objects such as bathtubs etc.

The cables must be gently attached so they are not damaged.

To ensure an accurate and easy installation of the cables, devifast™ fitting bands can be used.
The devifast™ fitting bands are equipped with attachment clips at intervals of 2.5 cm so the distance between the cable loops will be 5, 7.5, 10, 12.5, 15, etc.

The concrete around the cables must not contain sharp stones and should have a consistency enabling it to surround the cable completely without leaving air pockets.

The concrete should be applied very carefully in order not to damage the heating cables!

In connection with wet rooms (bathrooms etc.) a damp proof membrane should always be used in order to prevent moisture from entering the floor construction.

If the floor is built on the ground, a damp proof membrane is needed to prevent moisture from moving upwards and into the floor construction.

The wire of the floor sensor must be protected by a plastic pipe with a minimum inside diameter of 9 mm. The sensor must be positioned in the centre at an open end of a cable loop. Where the pipe is bent between the floor and the wall, the minimum bending radius is 6 cm. The pipe must be sealed at the end to prevent concrete from entering.

Should the cable become damaged while being laid out or later during the building process, it is a great advantage in the fault finding process to know the exact positioning of the connection box between the heating cable and the cold cable as well the end of the cable end, as the cable layout. It is therefore important to make a sketch showing the positioning of these things in the room.

The heating cable and the plastic connection box between the heating cable and the cold cable must both be cast in concrete. If the cable is pushed down into the insulation material or covered by it in any other way, the surface temperature can become too high, which might result in cable defects at worst.

At low temperatures (below 5°C) the cable can become difficult to handle due to the plastic sheath.

This problem can be overcome by connecting the cables for a short period. For this purpose
THE CABLE MUST BE ROLLED OUT! When the cable has become flexible again, the electrical flow should be disconnected. It is not recommended to lay cables at temperatures below - 5°C.

The floor heating must not be turned on before the concrete has fully set. It takes approximately 30 days for concrete and 7 days for moulding compound.

The resistance and insulation values of the heating cables should always be measured before and after the concrete is applied.

1. *Thousands of private homes enjoy comfort of DEVI floor heating system.*

2. *AUDI saloon in Vilnius, Lithuania is equipped with DEVI heating system.*

3. *Church in Yerevan, Armenia is heated with DEVI system indoors and outdoors.*

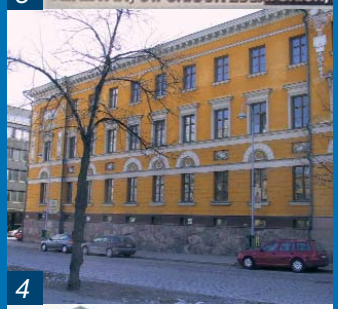
4. *Ministry of Defence in Helsinki, Finland is effectively protected with DEVI system for roofs.*

5. *New airport in Billund, Denmark has DEVI system for ground applications.*


1


2

3


4


5

DEVI™

DEVI A/S
Ulvehavevej 61
DK-7100 Vejle
www.devi.com

0809681