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

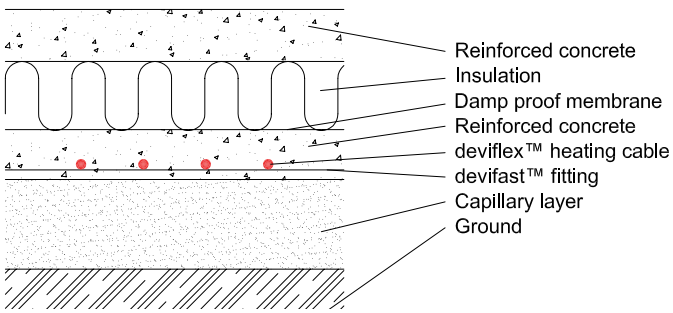
The installation of deviflex™ heating cables for frost protection purposes is performed in the same way as for ordinary concrete floor constructions.

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.