Metawell
metal sandwich technology

Metawell® floor heating system

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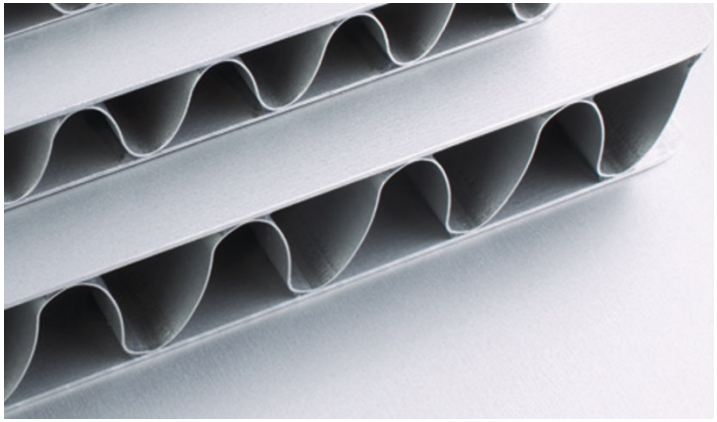
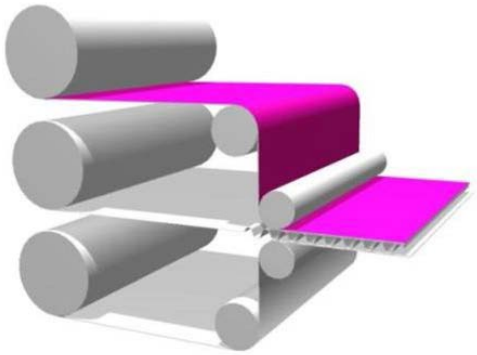


To meet the rising functional demands put on the construction of rail vehicle components, we are constantly in search of new ways to equip lightweight elements, such as floors, walls or ceilings, with additional features. This inspired the idea of using the corrugation channels of the Metawell® panel as heating elements.

The Metawell® aluminium sandwich panel has been implemented for more than 30 years and has established itself as a sustainable and corrosion-resistant lightweight floor panel.

This is how Metawell® is made:

In a continuous production process a thin aluminium sheet is formed into a corrugation and glued to two cover sheets.

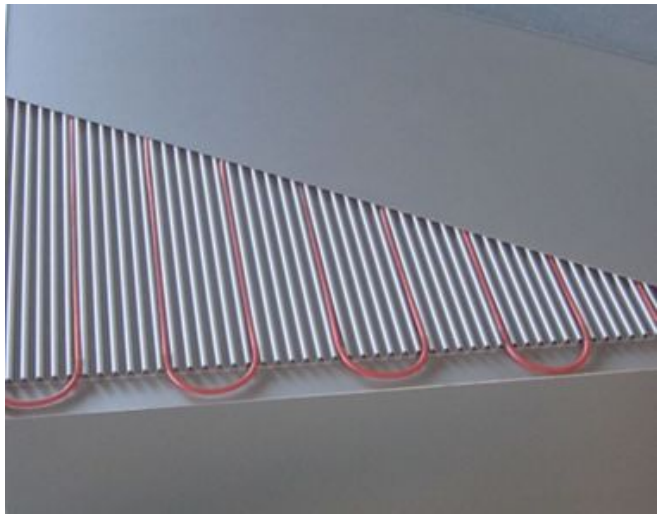


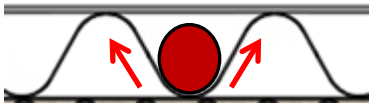
- ✓ Compared to solid materials, the sandwich has a high rigidity and leads to significant weight reduction due to the corrugated core
- ✓ The individual sheets are all coil coated with a corrosion primer which gives the entire structure, as well as the core layer, a reliable corrosion protection
- ✓ The corrugated core facilitates excellent heat conduction, thus making it possible to achieve a constant temperature distribution on the surface of the component

For the production of a heated panel, the Metawell® sandwich can be equipped with different heating elements.

Heating cable, integrated in the sandwich panel – a specific solution for the Metawell® panel

- ✓ The corrugation channels of the panel core are ideally suited to a meander-shaped installation of the cable.
- ✓ The cover sheets of the panel provide the cable with optimum protection from mechanical damage, squashing or damage due to sharp objects.
- ✓ Installing the cable near the surface makes the heating power highly efficient. The corrugation structure of the core helps to distribute the heat on the surface of the floor.

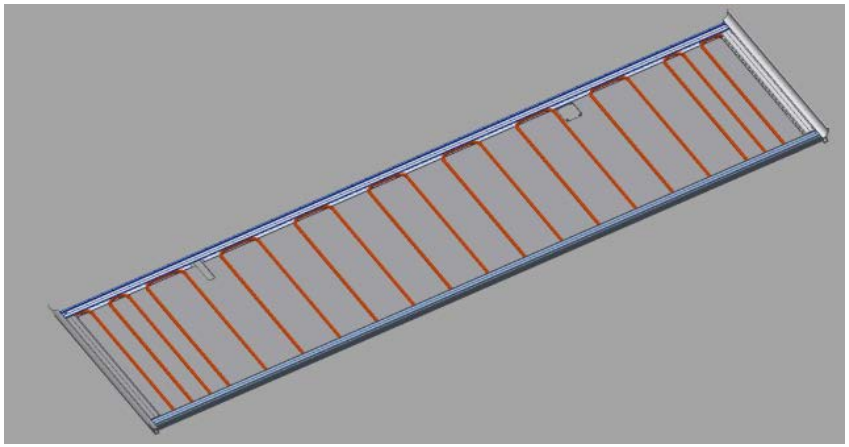


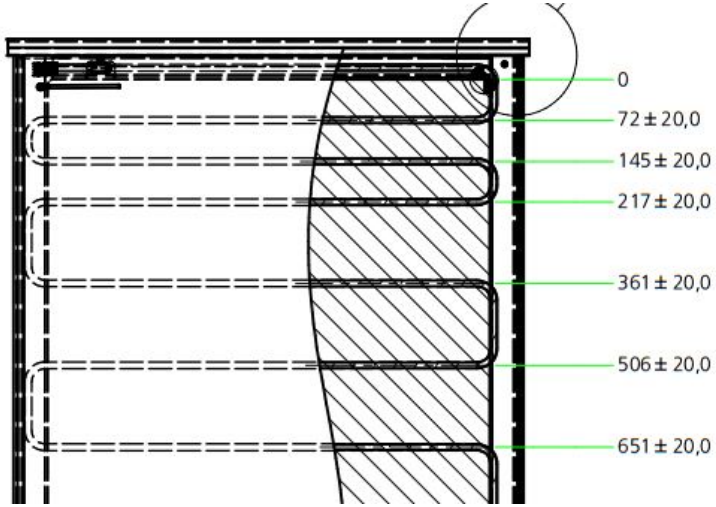


Operating voltage: Between 100 and 400 V/AC, depending on the supply voltage on the board

Heating power

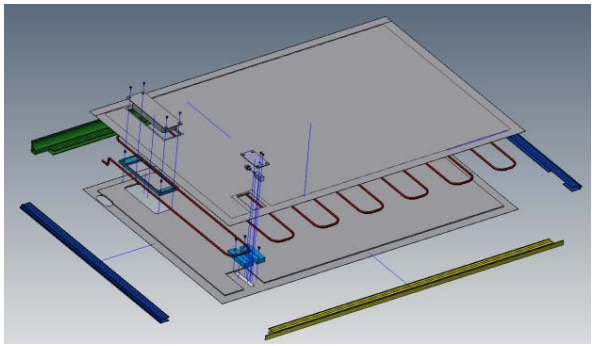
The heating power is determined by the installation density of the cable and can be varied if required.
Thus the heat output can be increased as required (e.g. along the exterior wall or at the entrance)
The heating power of the component is generally between 150 and 600 W/m².

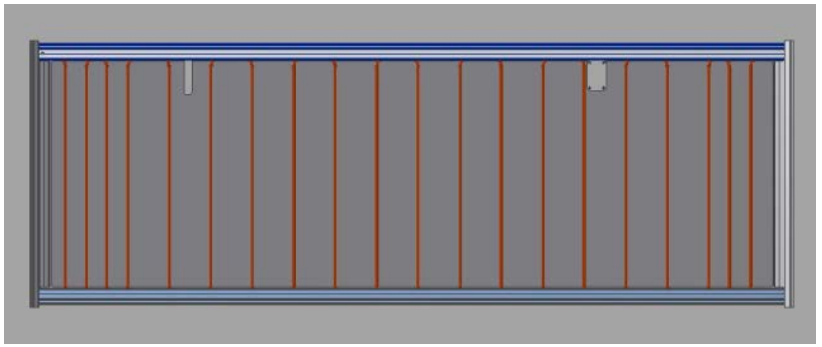




Laying the cable in the panel

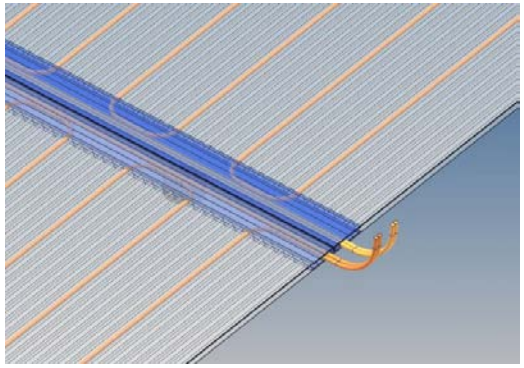
The sandwich panel requires a certain thickness to incorporate the heating cable. Suitable panel thicknesses are between 10 and 20 mm.
The cable is laid by pulling it meander-shaped through the corrugation channels of the panel. It is optimally protected by the cover sheets of the panel. The position of the cable in the panel facilitates any desired positioning of the supports and other attachment parts.
Although the position of the boreholes and apertures has to be clarified beforehand, it is possible to make alterations at short notice without new tools having to be constructed.
The position of the cable ducts can be marked on the plan, so that it is subsequently possible to mechanically rework the panel in the cable-free areas.

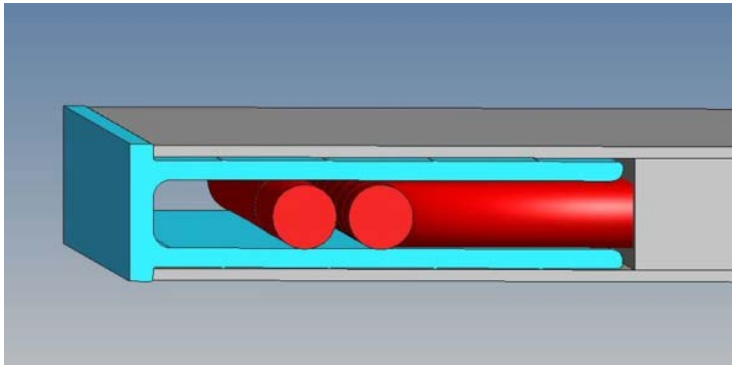




Edge finishing

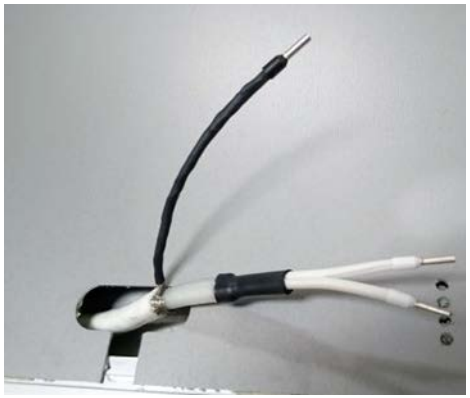
The edge of the panel with cable bends is closed with a profile, which is glued into the panel.
Thus the panel is heated to the outer edge.
To additionally heat the massive panel joint, it´s also possible to lay the cable in the hollow chamber of the edge profile.





Cable outlet and connection

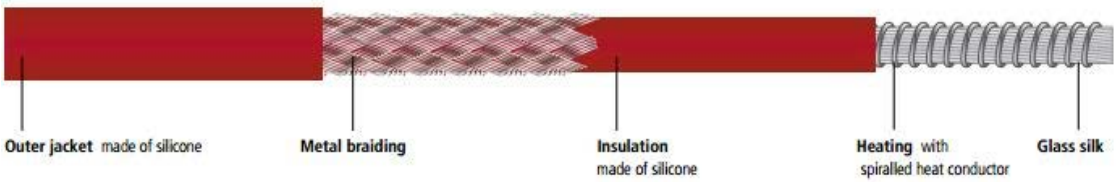
The cable outlet should preferably be placed at the edge of a panel.
For this purpose, there´s a small milled-out groove in the panel.
The connection is via the end sleeves, or on request, the installation of an on-board matching plug is possible.



Overview of the different cable types

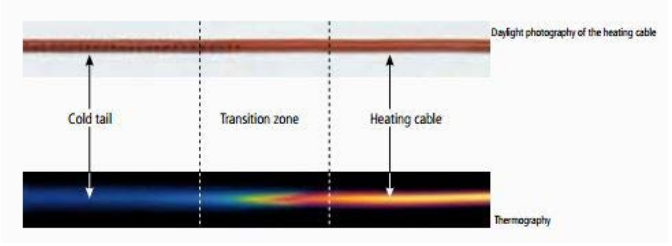
1. Heating cable with two sleeveless cold leads

- ✓ The heating wire is wrapped spirally around the supporting material (glass silk), so that it is protected against tensile overuse.



Picture: heating cable by Winkler GmbH

- ✓ Silicone insulation
- ✓ Covering (metal braid) for mechanical protection; can be used as direct earthing
- ✓ Outer silicone jacket for a noiseless usage of the cable inside the Metawell® panel
- ✓ Connection via two 2-wired cold leads (conductor + grounding)
- ✓ Sleeveless transition from hot tail to cold tail



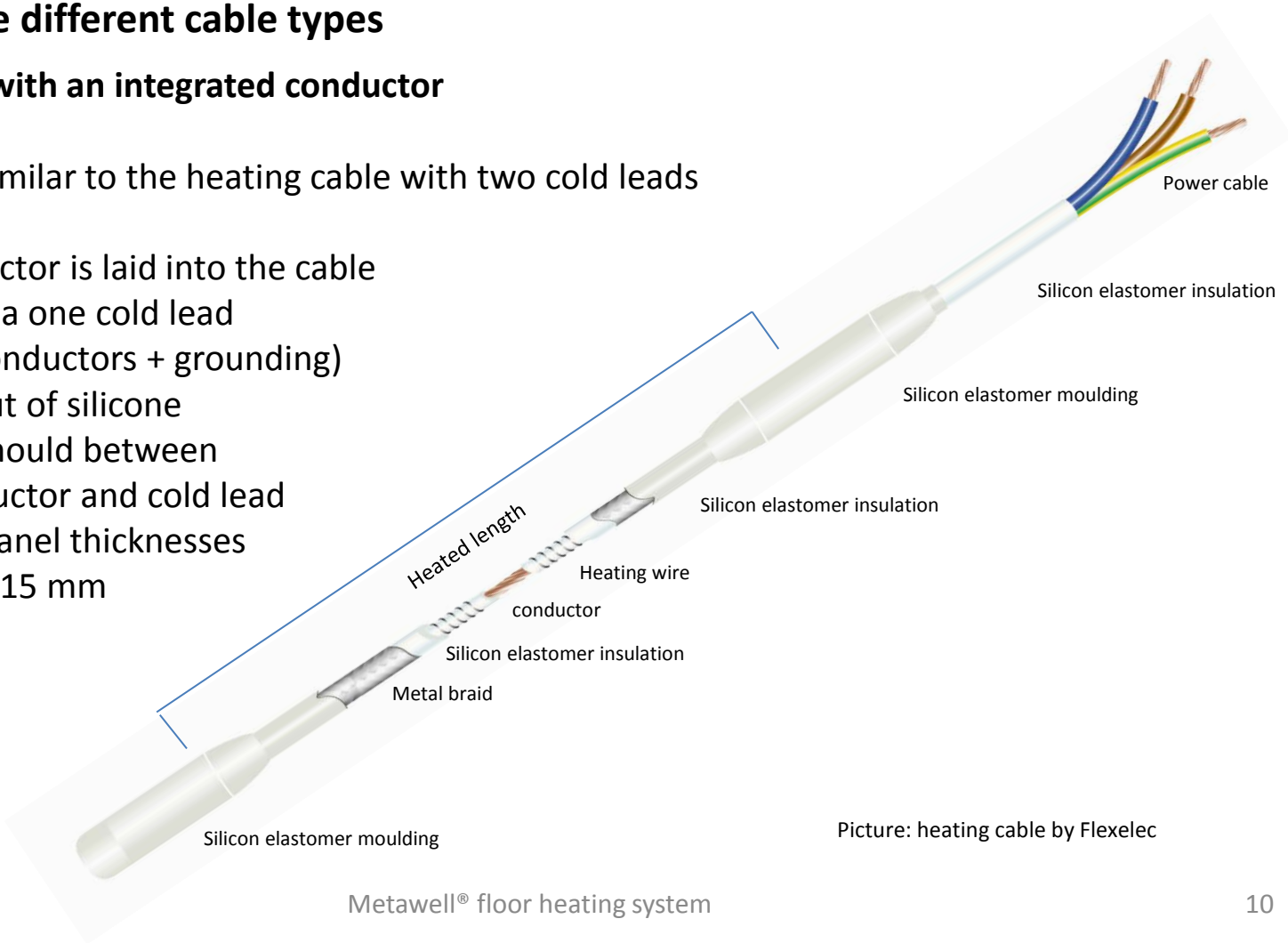
- ✓ Customized lengths
- ✓ On-site adjustments are not possible; the length of the cable has to be defined in advance

Overview of the different cable types

2. Heating cable with an integrated conductor

The structure is similar to the heating cable with two cold leads

- ✓ Return conductor is laid into the cable
- ✓ Connection via one cold lead (3-wired, 2 conductors + grounding)
- ✓ End mould out of silicone
- ✓ Connection mould between heating conductor and cold lead
- ✓ Suitable for panel thicknesses starting from 15 mm



Picture: heating cable by Flexelec

Overview of the different cable types

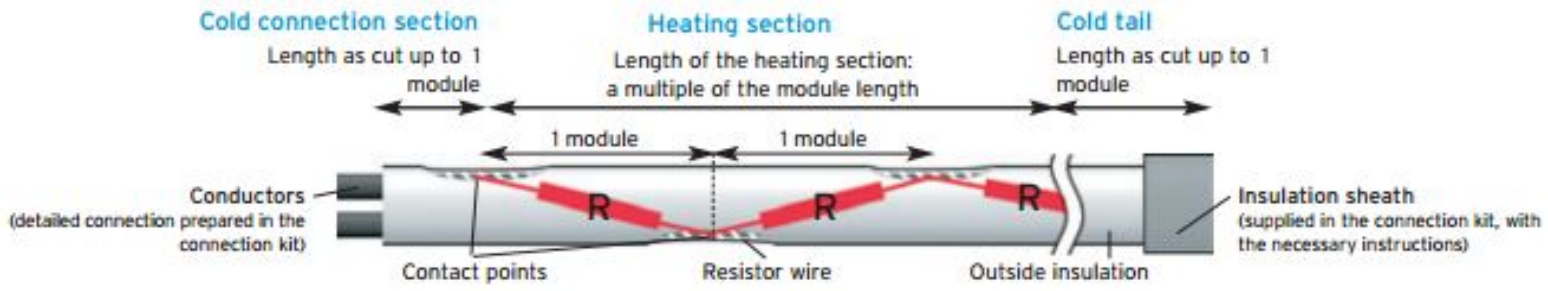
3. Parallel heating cable with modules

3.1 Principle

- ✓ Identical resistors (modules) connected in parallel
- ✓ Two conductors laid in the cable
- ✓ Connection of every module with the conductor takes place at the contact points (soldered)
- ✓ Every module has the same heating power P_i
- ✓ Total power of the cable: sum of power of each module

  $P = n \times P_i$

  (n – number of modules)

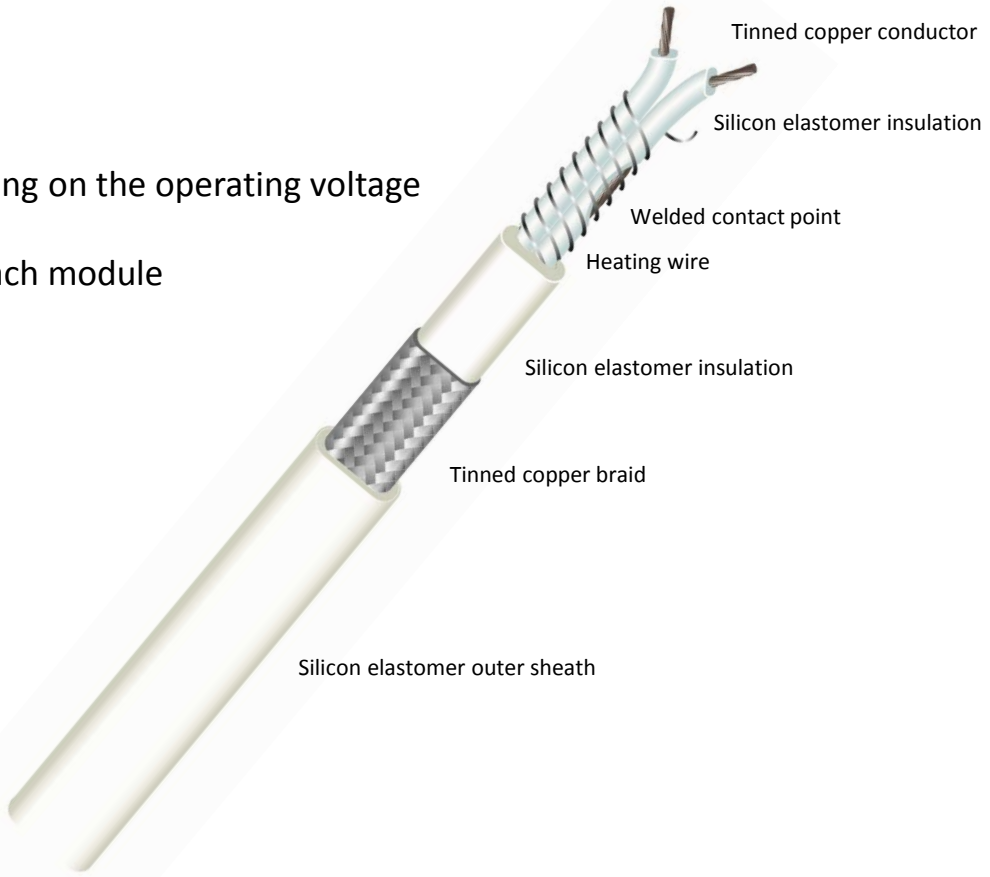


Picture: heating wire of „Flexelec“

3. Parallel heating cable with modular units

3.2 Characteristics

- ✓ Module length between 0.5 and 0.9 m (depending on the operating voltage and the heating power of the cable)
- ✓ Available by the metre; can be cut on-site for each module
- ✓ Adjustment of the component´s heating power is also possible at short notice
- ✓ Power between 25 and 50 W/m
- ✓ Every module has the same heating power P_i
- ✓ Connection via a 3-wired cold lead (2 conductors + grounding)



Picture: heating cable by Flexelec

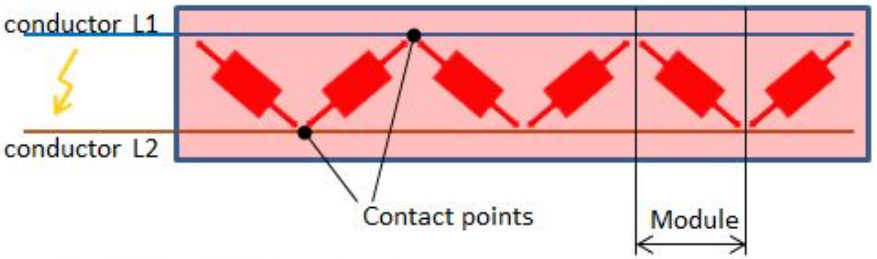
3. Parallel heating cable with modular units

3.2 Module failure

Total power of the cable:
sum of power of each module

$P = n \times P_i$

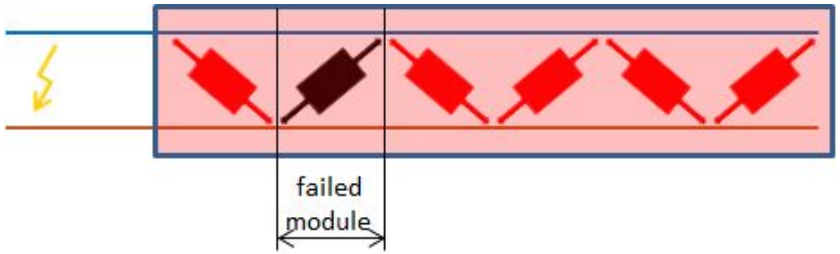
(n – number of modules)



Heating cable with 6 modules:
$P = 6 \times P_i$

Even if one module fails, the remaining modules continue working. Total performance decreases only by the heating power of the failed module:

$P_{defect} = (n\text{-}1) \times P_i$



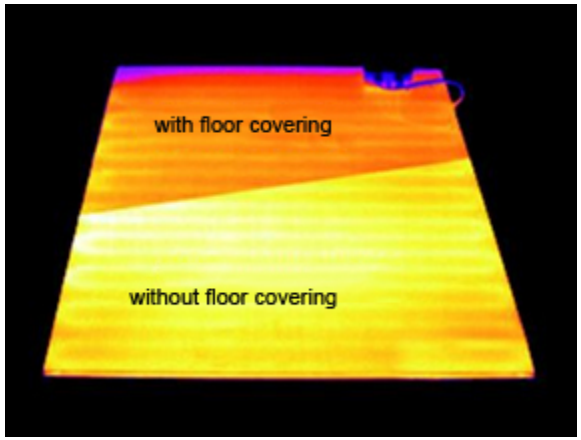
Heating cable with 6 modules, one of them is failed:
$P_f = 5 \times P_i = 5/6 \times P = 83\%$ von P

Temperature measurements

The implemented heating tests confirm a good, constant heat distribution on the panel surface. The temperature difference between different measuring points on the surface remains lower than 5 K.

The time of warming up and the maximum rise in temperature are determined by the following factors:

- ✓ Heating power of the component
- ✓ Insulation
- ✓ Surface (floor covering)
- ✓ Air flow in the surrounding area
- ✓ Heat capacity of the component

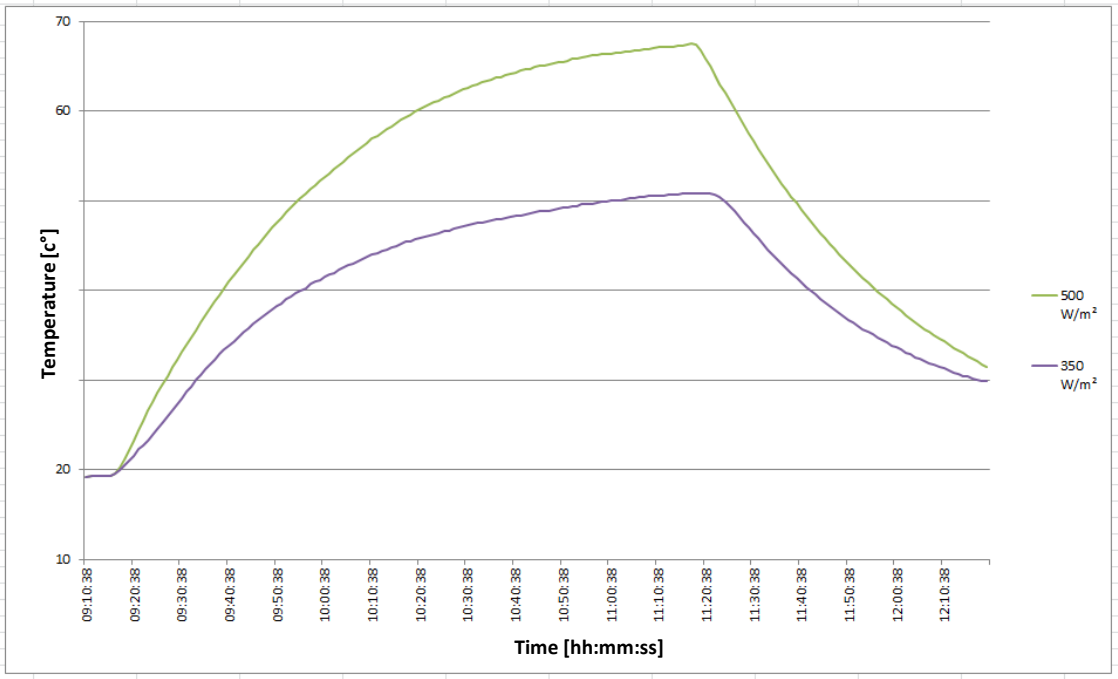


Temperature measurements

Basic heating tests were performed at full power and without regulation, to identify the maximum temperature increase dependent on the heating power.

Tested panel type :
Height 15 mm
Weight 7.3 kg/m²

Expample ΔT-values:
At 500 W/m² - ca. 45 K
At 350 W/m² - ca. 30 K
At 300 W/m² - ca. 20 K
At 200 W/m² - ca. 14 K



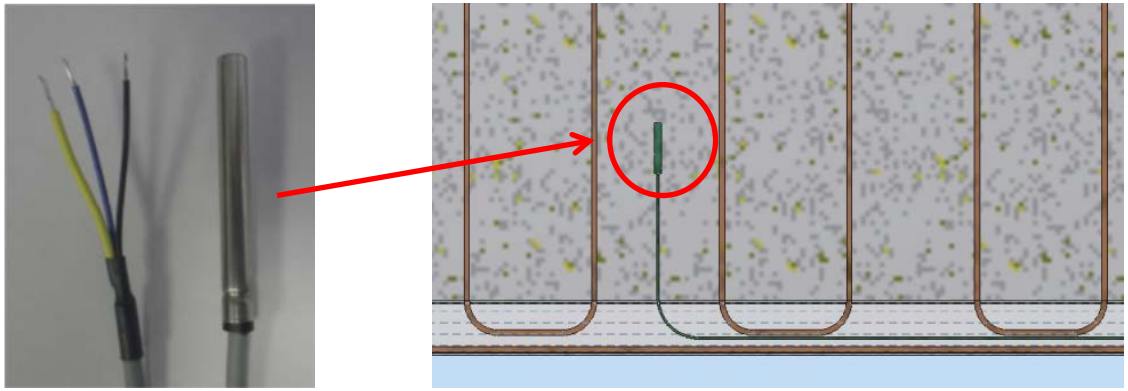
Temperature control

Temperature sensor

The easiest way of controlling the temperature is to use a resistance thermometer:

- ✓ PTC-series - electrical resistance increases with the rise in temperature
- ✓ NTC-series – electrical resistance decreases, while temperature increases

The sensor transmits the electrical signal to the control system of the HVAC-system of the vehicle.



Example: A platinum sensor (e.g. PT1000) can be installed in the Metawell® panel.

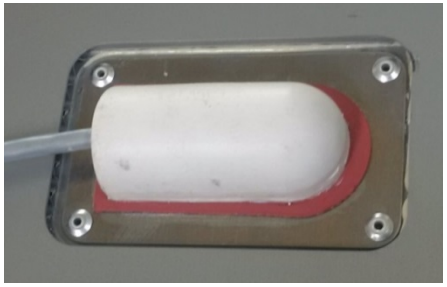
Temperature control

Over-temperature switch

An additional thermal cutoff is provided by an over-temperature switch (limiter) that can be installed in the Metawell® heating. This includes a bimetal switch that effects an opening of the electric circuit as soon as a certain temperature is reached. Depending on the strength of the current, the limiter can be integrated into the heating circuit or used as a control signal.
In selecting the limiter, the following factors are taken into account:

- ✓ Operating voltage
- ✓ Switch temperature
- ✓ IP-protection class
- ✓ Number of switching cycles

The bimetal switch has solely a safety function and should not be used for regulation.



References rail vehicles

- ✓ *Bombardier Transportation*, TRAXX-locomotive
  - heated floor in the driver´s cabin

- ✓ *Skoda Transportation*, Regio Panter
  - heated floor in the entrance area

- ✓ *Stadler Rail AG*, EC250
  - heated floor in the passenger area, entrance area and the driver´s cabin

References cable car construction

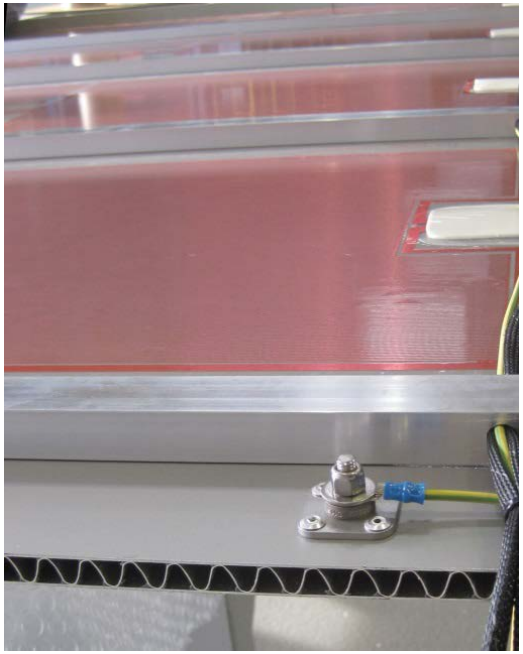
- ✓ *Fa. Carvatech*, aerial tram cabin Monte Bianco
  - heated cabin floor
- ✓ *Fa. Carvatech*, aerial tram cabin Lech-Oberlech
  - heated cabin floor

Other types of heating elements

If it is not possible to install the heating cable (e.g. in the case of a thin panel or if the heated area is very small) other heating elements can be used.

Foil heating

The heating foils are glued under the Metawell® panel.
The usage of the foils is appropriate for thin sandwich panels, if the integration of a heating element in the panel core is not possible.



Advantages of the system:

- ✓ Low construction height
- ✓ Different heating density within one foil is possible
- ✓ Easy installation under the panel

Disadvantages of the system :

- ✓ Low flexibility with dimensions
- ✓ High mold costs
- ✓ Sensitivity of the foils
- ✓ Position of supports and holes must be defined before the foil production
- ✓ Design change of the components usually requires the construction of new molds

Other types of heating elements

Silicone mats with a vulcanized heating wire

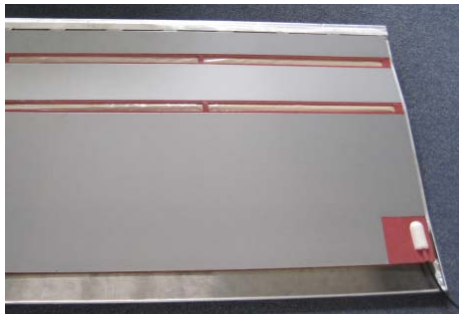
The mats are glued to the underside of the panel:

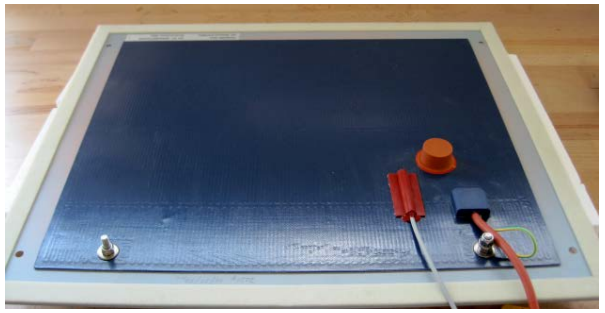
Advantages of the system:

- ✓ Heating wire is well protected due to the silicone
- ✓ Flexible adaption of the heating density within a mat
- ✓ Also suitable for panels with smaller dimensions (e.g. entrance area)

Disadvantages of the system:

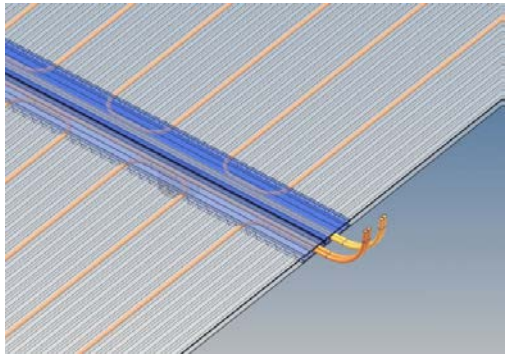
- ✓ Specific construction height of the mats approx. 3 - 4 mm
- ✓ Weight of the mats
- ✓ Labor-intensive production

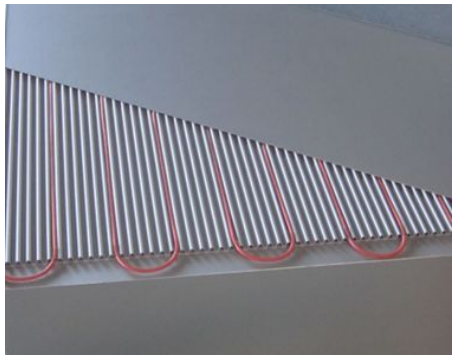




The integrated Metawell® floor heating with heating cable - advantages at a glance:

- ✓ Optimal protection of the heating cable inside the panel
- ✓ Flexibility in dimensioning heat density
- ✓ Simple combination of heated and unheated floor panels
- ✓ No tool costs
- ✓ Maintenance-free system
- ✓ Very good heat distribution
- ✓ Positioned close to the surface
- ✓ No EMC interference
- ✓ Halogen-free components





Certification

- ✓ Fire protection in accordance with EN 45545-2
- ✓ Vibration test in accordance with EN 61373