TECHNICAL DOCUMENTATION

OPAL SYSTEMS

Your reactive floor heating

www.opal-systems.be

1. CONTENTS

1. UNDERFLOOR HEATING RADIANT – GENERAL

1.1. LOW TEMPERATURE HEATING

- Radiant heating appears to be a solution that fully meets the challenge of reducing energy consumption. It is the indispensable emitter to benefit from systems whose high yields are dependent on the production of low-temperature heat.

- Although this type of heating has a limited emissive power compared to high temperature systems, this is no longer a drawback. Indeed, the strengthened and compulsory thermal insulation of buildings reduces waste and thus the need for powerful systems or costly-to-operate space heaters.

- The added value of a building due to its lower energy consumption makes it possible to justify an investment in an efficient heating system.

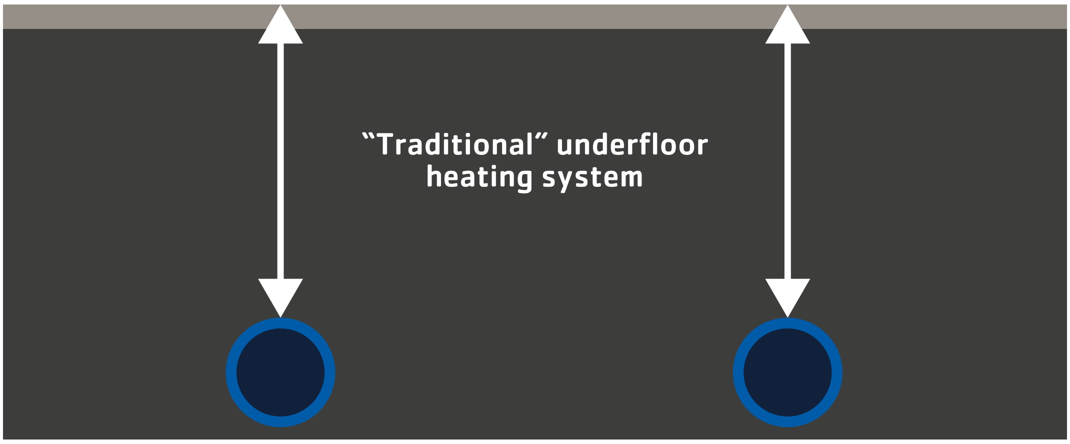
1.2. UNDERFLOOR HEATING

- Among the different emissive systems used for heating buildings and houses (radiator, fan convector, pulsed air, screed convector, etc.), water-based underfloor radiant systems are considered to be the most efficient and provide the best thermal comfort for occupants.

- These systems usually comprise pipes arranged in a meandering or bifilar spiral pattern, through which hot water flows, embedded in a concrete screed on which the finish flooring is laid (tiles, wood floor, etc.).

1.3. THE OPAL-SYSTEMS SOLUTION

- • In order to allow operation with water which is the least hot as possible and to increase the responsiveness of the heat emitter, the OPAL system has been designed to reduce the thermal resistance between the water pipes and the surface of the floor and the thermal inertia of the entire emitter. This is in order to improve thermal comfort as well as the overall energy efficiency of the heating system.



1) 1) The thermal inertia of the heating system is an obstacle to its responsiveness:
  → is detrimental to comfort
  → results in waste

2) Installation time is long.

- A spin-off of the University of Liege founded in December 2009, OPAL-Systems s.a. designs, manufactures and installs its concept of underfloor heat emitter which combines the known advantages of underfloor heating while reducing its drawbacks.

- OPAL-Systems has established itself as a benchmark in the field of thermal comfort and energy savings for buildings in the residential and tertiary sectors, both in new construction and in renovation.

- OPAL-Systems has worked to provide a comprehensive service to its customers by carrying out nearly 1,000 projects in Belgium, the Grand Duchy of Luxembourg, Switzerland, France and the Netherlands.

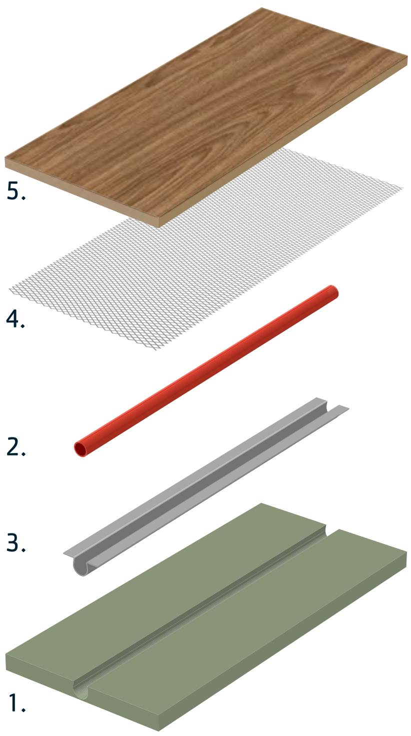
2. GENERAL COMPOSITION OF THE EMITTER

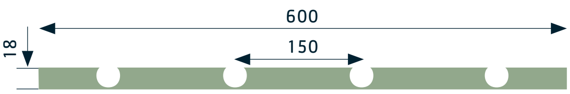
2.1. BONDED FINISH FLOORING – TILING OR WOOD FLOOR

In order to reduce the distance between the pipes and the surface of the emitter, the following system has been adopted:

Water-repellent MDF boards (1) are laid on a stable, flat, thermally insulated substrate. Grooves 16 mm in dimension have been milled into these boards in order to introduce a pipe (2), suspended thanks to aluminium diffusers (3) whose role is to "draw" the heat upwards towards an aluminium mesh (4).

Tile or wood floor (or resin) flooring (5) can then be laid (poured) on the whole with cement glue which will completely coat the metal mesh thereby distributing the heat efficiently and directing it upwards. This mesh also improves the adhesion of the finish flooring and helps strengthen the entire structure.

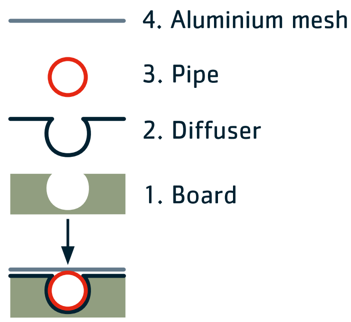




Board weight 0,6 x 1,22 m: 7,2kg

DESCRIPTION OF THE SECURING SYSTEM:

To keep it firmly, as close as possible to the surface of the floor and with the best thermal contact possible with the aluminium mesh (4), the pipe (3) will be wedged in the groove using an omega-shaped metal diffuser (2).



These omega-shaped diffusers (2) are aluminium profiles, one metre long. They protect and hold the pipe in place, and conduct the heat upwards.

An air space exists under the diffuser. It reduces heat loss by downward conduction. Radiation losses are also reduced since the emissivity of the underside of the diffuser is low.

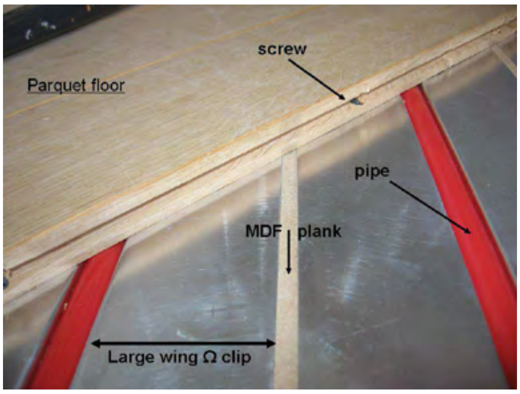
This configuration (pipe suspended by the diffuser) avoids stresses induced by the vertical loads applied to the floor above the pipe and makes a certain longitudinal movement possible (dilation).

Example of direct laying of tiles on the emitter with flexible mortar-glue.

It is also possible to directly glue a wood floor using PU glue for example.

2.2. UNBONDED FINISH FLOORING

For unbonded finish flooring, the layout of the boards, pipes and diffusers is identical. On request, the horizontal parts of the omega-shaped diffuser can be wider, thus replacing the metal mesh.



As shown in the pictures above, the floor can be floating or secured to the MDF boards of the OPAL system. In this case, care must be taken not to damage the pipe with the screws or nails securing the floor.

3. SPECIFICITIES AND ADVANTAGES OF OPAL-SYSTEMS TO MEET TECHNICAL-ECONOMIC NEEDS.

3.1. ADVANTAGES RELATING TO THE CHARACTERISTICS OF THE HEAT EMITTER

3.1.1. Installation

- No use of special techniques
- With a reduced number of workers on the site
- In a shorter time frame:
  - no waiting time for a screed to dry
  - no gradual warm-up procedure to follow
  - no expansion joint, peripheral joint or dummy joint
  - to be planned or made
  - no polyethylene film to prevent moisture from entering the screed to be planned or installed
  - no hydraulic balancing required for the underfloor heating pipes

In particular, wood floor firms recommend a drying time of 15 to 20 weeks for wet substrates (screeds). This period can be shortened by 4 to 6 weeks by inserting an underfloor (OSB boards) between the screed and the wood floor. This underfloor can be OPAL-Systems underfloor heating!

3.1.2. Reduced volume and weight

- OPAL-Systems is suitable for the renovation market because:
  - its small volume (≈ 2 cm thick) becomes a decisive advantage when ceiling height is limited or floor-level adjustments are required.
  - its lightness (12 kg/m² filled with water) means it can be considered even in the case of a house whose floors will not support the weight of a concrete screed.

3.1.3. Modularity

- Coverage of the entire surface (floor and wall) of premises of all shapes and dimensions.
- Suitable for renovation or new construction, traditional or otherwise.
- It adapts harmoniously to wood construction:
  - its lightweight design allows it to be installed even on upper floors
  - the installation substrate can be entirely of wood with insulation that uses only natural materials
  - its maximum regulatory power is higher than in some dry systems for which the pipe is not laid out in a bifilar spiral.
- For multi-storey buildings, its limited volume will allow the size of the building to be reduced or allow an additional floor to be built.

3.1.4. Choice of constituent materials excluding products hazardous for the environment

Recycled wood boards: CE certified lightweight water-repellent MDF.
Thickness: 18 mm
Density: 640 kg/m3
Tensile strength EN 319: 0.45 N/mm² Flexural strength EN 310: 18 N/mm² Modulus of elasticity EN 310: 1600 N/mm²
Perforation strength (35.6 mm diameter cylinder for an indentation > 0.2 mm): 4,770 N

Formaldehyde according to the "perforator" method - Class E1: 8 mg/100 g
The MDF board meets the EN 622-5 specifications, option 1, cyclic test, where the board is soaked in water, frozen and finally dried. This cycle is repeated 3 times. The board producers support sustainable forest management and have the PEFC (Programme for the Endorsement of Forest Certification Schemes) and FSC (Forest Stewardship Council) certificates.

The Blaue Engel is a German environmental marking, which indicates why the MDF board is greener than similar products.

FSC PEFC

Diffusers:
Made from pure aluminium.

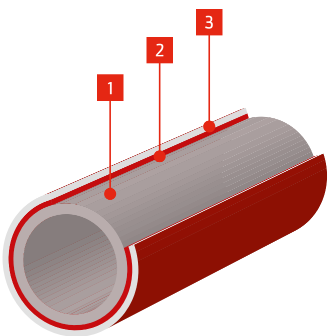
Mesh:
Made from pure aluminium.

Pipe:
RAUTHERM S Pex-A 16 x 1.5 CE certified
The pipes (PEX-a) comply with the DIN 16892, DIN 4726 and DIN 4729 standards. Thermal conductivity [W/(m·K)] 0,35
Tube rugosity [mm] 0.007
+Working pressure (max.) [Bar] 6 Operating temperature (max.) [°C] 90
Short-duration maximum temperature (fault) [°C] 110 Oxygen diffusion (according to DIN 4726) – oxygen-tight Minimum installation temperature: 0°C
The coils will be individually protected against ageing due to light (UV) and possible damage during their storage.

RAUTHERM RAU-PER
Anti
Oxygen
Barrier

1 RAU-PER pipe, white
2 PE red, opaque, co-extruded coating
3 EVAL, transparent, co-extruded coating

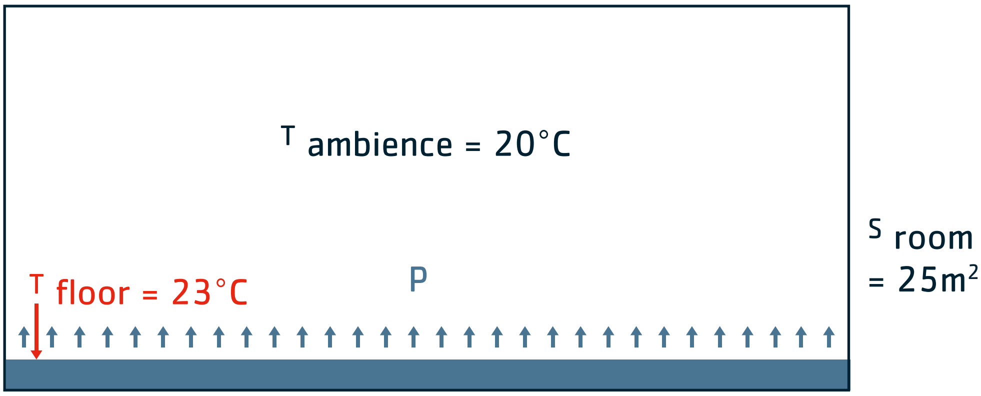
Technical opinion No. 14/04-875



3.2. PERFORMANCE

3.2.1. Incorporates the known advantages of underfloor heating

- Excellent thermal comfort thanks to:
  - Ideal temperature distribution according to the height of the room to be heated (from the feet to the head of the occupants).
  - An increase in the proportion of radiant heat emissions that are more efficient and do not create a movement of air and dust.
  - A higher relative degree of air humidity is achieved in a lower temperature environment
  - a significant self-regulating effect. This effect is well known in relation to low-temperature emitters and results in an automatic increase (decrease) in emissions when the ambient temperature drops (increases) as heat gains appear (disappear) in the room.



Emissive power mid-season

$P\ 11 \times (T_{floor} - T_{ambience}) \times S = 11 \times (23 - 20) \times 25 = 825\ W$

$= 11 \times (23 - 21) \times 25 = 550\ W$

→ Self-regulating effect of underfloor heating: 825 W at 20°C becomes 550 W at 21°C → - 33%

- Low stratification and warm walls mean the air temperature of the room to be heated and consequently energy consumption can be reduced, without affecting thermal comfort (ideal for high ceilings). Without loss of comfort, the average temperature of the air volume of an underfloor-heated room can thus be reduced by +/- 2° C compared to the same room heated by radiators. This difference alone represents an energy saving of 12% on the energy bill!

- A large exchange surface allowing, for equal power, to reduce the temperature of the heat transfer fluid

- No visible heat emitter
  - -More aesthetic
  - -Allows space-saving and greater freedom in using the rooms and placement of the furniture

- Does not require maintenance. In addition, "faster drying after mopping tiles (this minor benefit may make some people smile, but it changes the life of the person who has to do it)"

3.2.2. Works with a low-temperature heat transfer fluid

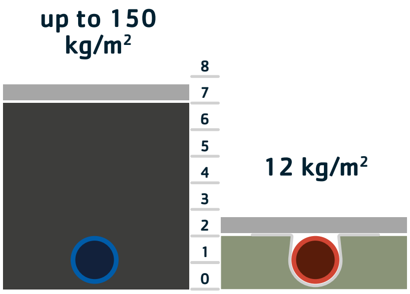
Its ability to work with a low-temperature heat transfer fluid allows:

- Connection to high-efficiency heat producers such as heat pumps, condensing boilers, co-generation systems and possibly allows more intensive use of solar thermal energy for heating buildings.

- Reduced losses in producing, storing, distributing and emitting heat.

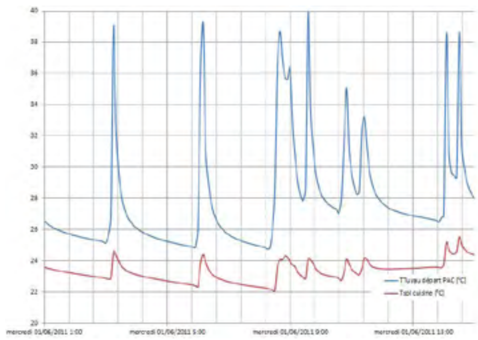
• 3.2.3. OPAL-SYSTEMS ADVANTAGES: Lightweight and low inertia

Comparison between "heavy" underfloor heating under a screed and "lightweight" OPAL-Systems



	System under a screed	Opal-Systems
Thickness	+/- 7 cm	2 cm
Weight	+/- 150 Kg/m²	12 Kg/m²
Responsive-ness	Low	Immediate
Intermittency	Difficult	Possible
Various		
Drying	Necessary	None, because no screed
Plaatsing	Structural work	Finish

- High responsiveness to variable heat demands

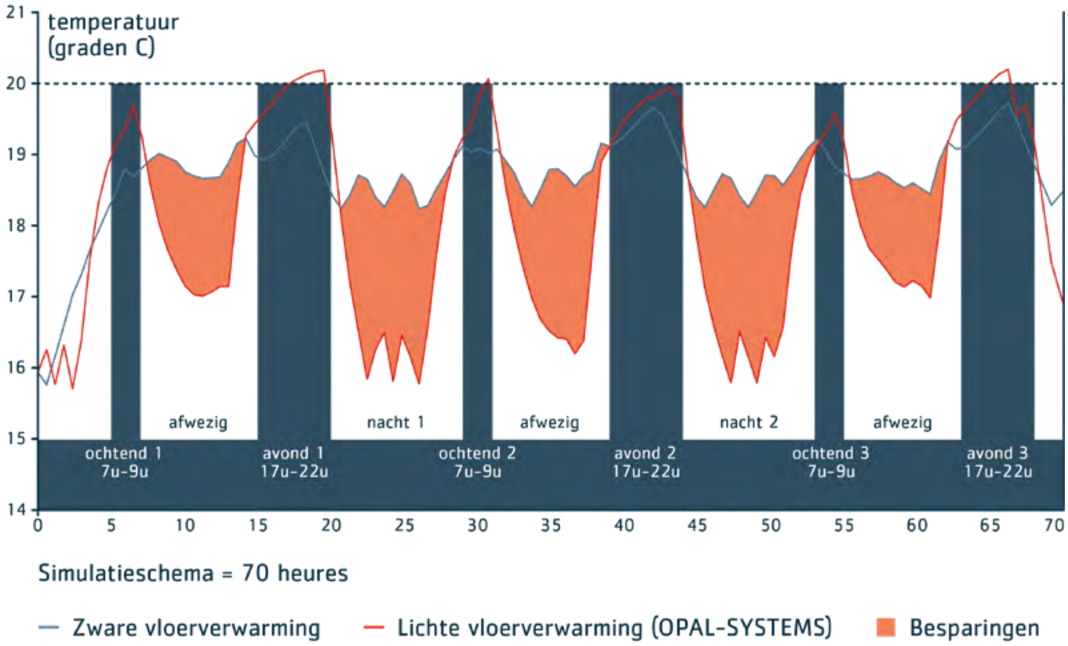


It takes 10 minutes between the moment hot water starts to flow through the pipe for a temperature rise to occur on the tiled floor surface (see attached graph).

- Reduced risk of overheating and energy wastage due to random heat inputs (solar or internal gains)

- Allows the operation of intermittent installations (shut down in the absence of occupants or during the night), allowing substantial energy savings to be made.

The simulation (see graph below) shows that, in the absence of occupants (from 9:00 to 17:00 and during the night), it is possible to slow down heat emission with a lightweight OPAL-Systems system. In this case, which takes into account emission reductions due to solar gains, a reduction of about 17% in annual energy consumption is calculated. The weather data is that recorded in Saint-Hubert (B).



- OPAL-Systems fully heats premises without using additional radiators to boost recovery after an unheated period.

3.2.4. Suitable for heating and cooling of premises

- Can be used for floor and wall heating
- More uniform temperature distribution
- Simplified and modular pipe circuits to better distribute the emitted power, improve the uniformity of the temperature of the room to be heated and reduce pressure losses for the circulation pump
- Maximum floor surface coverage
- Higher maximum power (without exceeding the maximum regulatory surface temperature) thanks to the bifilar spiral layout of the pipes
- Max. heating power: =~ 90 W/m² at 20°C.
- Max cooling power: =~ 50 W/m² at 25°C.

3.2.5. Reliable

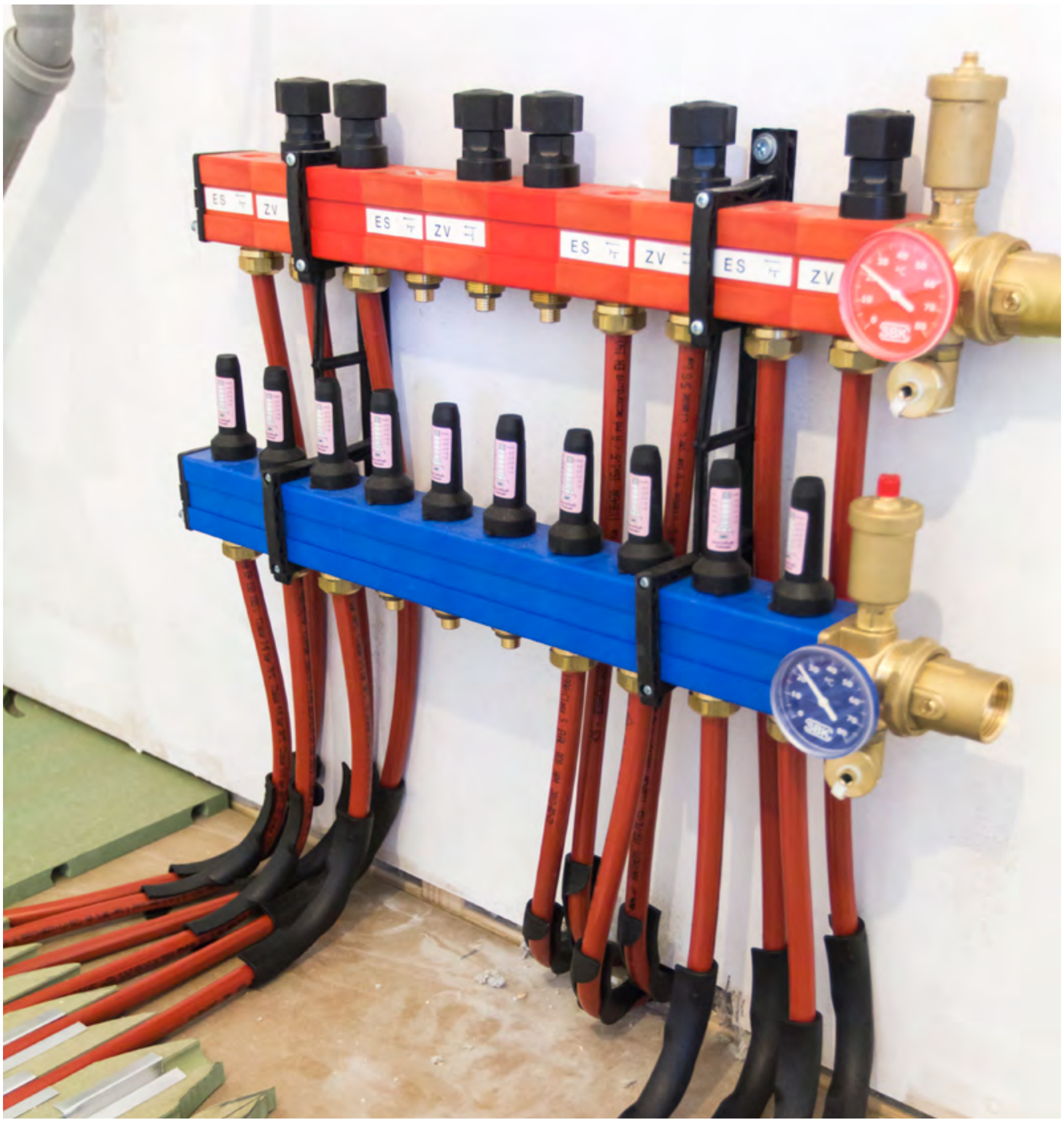
- Use of common materials in construction
- Ease of manufacture
- Can be disassembled (for adaptation or repair)
- A unique combination reinforcing and improving the adhesion of the bonded or poured finish flooring and the horizontal diffusion of the heat;

4. DISTRIBUTION

The underfloor heating pipes are supplied with hot (or cold) water from a manifold (feed) connected to a hot (or cold) water production machine such as a boiler or heat pump.

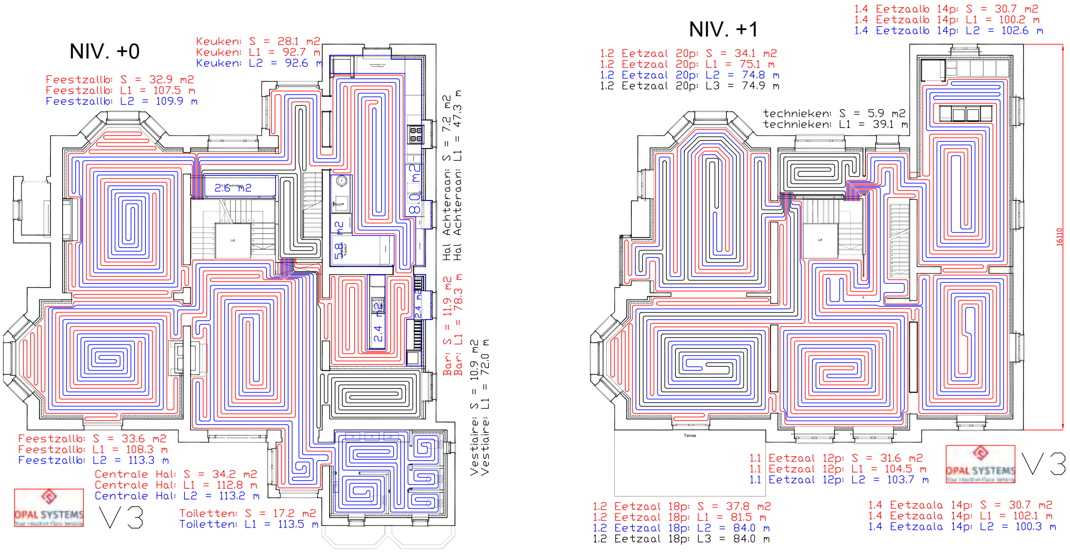
Due to the geometry of the OPAL-Systems emitter, the pipes belonging to the same thermal area have the same length and no balancing between them is necessary.

The water flows in these pipes can be adjusted by a single valve.



1. LAYOUT

A floor heating layout diagram showing the location of the pipes is proposed. It takes into account the definition of thermal areas established by the occupant or architect.



Similarly, no balancing is necessary between the pipes covering different thermal areas.

In fact, it is not useful to restrict certain shorter circuits, as is the case with "heavy" emission systems that do not allow or allow little local control, room by room, and for which the flows have been predefined on the basis of the supposedly invariable "nominal" requirements of the premises.

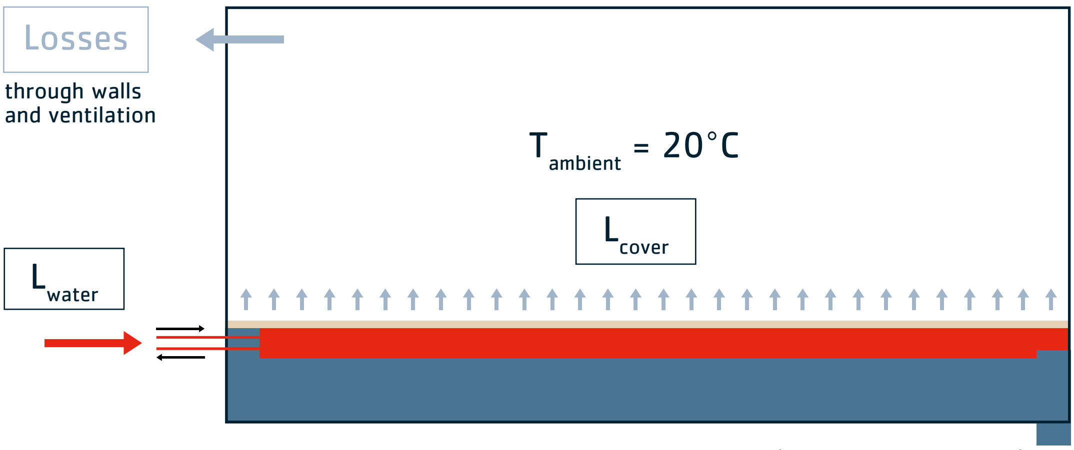
For energy-saving reasons, it is possible to use a variable speed water circulator that will maintain a constant feed pressure for all circuits, regardless of the total water demand of the manifold. The supply pipes of the manifold should be sized according to their lengths and maximum water flow.

6. CONTROL

The different rooms of the same building have different and highly variable needs which exactly match their heat losses (positive or negative). These losses depend on the ambient comfort temperature setpoint imposed by the occupants as well as the internal inputs (human presence, equipment, lighting, etc.) and external inputs (solar gains, etc.).

Thermal balance

$$L_{water} = L_{cover} = \text{Losses}$$



P_{water} = specific heat of the water x water flow x (T_{water_inflow} - $T_{water\_outflow}$)

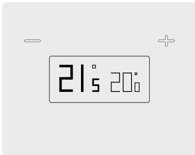
The setpoint and internal inputs vary mainly according to the occupancy rate, while external inputs depend on weather conditions.

To maintain thermal comfort in the different rooms, the additional heat sources of emissive systems must constantly offset these highly variable losses as closely as possible.

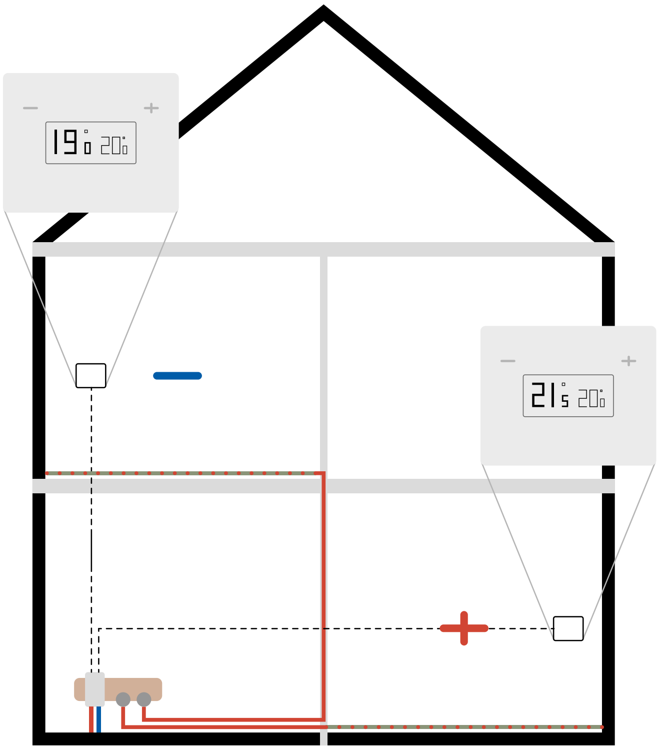
In the case of the OPAL system, this is achieved by varying the water flows in the pipes supplying the different premises according to the demands (thermostatic control).

In a building, the areas with different heat requirements are identified and for which independent control appears necessary. These are the "thermal areas". See previous "Layout" paragraph.

A room thermostat can be installed in each area. It will be used to measure the ambient temperature and to indicate the setpoint requested by the occupant. If the setpoint is higher than the room temperature, a "room demand" signal is sent to the valve that controls the water flow to the room in question.



This transmission can be made via electrical wires or radio waves ("wireless"). In the first case, wires (3 x 0.75 mm²) must have been installed that connect each room thermostat to the electrical terminal located near and above the manifold.



If a room demands heat, a small motor will operate the valve body on the manifold to allow water to flow to that room.

If the demand is reached or exceeded, the circulation of hot water is shut off.

7. OPAL-SYSTEMS PRINCIPLE OF SIZING AND ADJUSTMENTS.

1. A QUESTION IS OFTEN ASKED:

WILL MY UNDERFLOOR HEATING BE POWERFUL ENOUGH TO ENSURE COMFORT IN MY HOME, EVEN IN THE MIDDLE OF WINTER?

HLike any underfloor heat emission system, the power of OPAL-Systems is limited by the maximum permissible temperature for the upper face of the finish flooring.

In fact, for medical safety issues regulated by law, this temperature cannot – in general – exceed 29 °C. It is the EN 1264 standard that is applicable for hydraulic built-in heating (and cooling) surface systems. As a result of this limitation, the maximum emissive power of an underfloor heating system is approximately 100 W/m².

2. FLOWS

- Because the OPAL-Systems underfloor heating system operates at a variable water flow rate, it does not require pre-adjustment of the water flows in its pipes. These adjustments are usually made on the manifold by means of flow-control valves.

For OPAL-Systems underfloor heating, water circulation in all pipes must not (save exceptions) be restricted and all flow-control valves must be fully open This is the case, even if the pipes attached to a manifold have different lengths to serve the different rooms. It should be noted that, by construction, the lengths of the pipes serving the same room are virtually identical.

As with radiators fitted with thermostatic valves, the water flows in the various pipes will be continuously adapted automatically to respect the ambient comfort conditions imposed by the occupant - (thermostatic regulation).

This will maintain the temperature to the setpoints as closely as possible, room by room and hour by hour, whatever their needs. These needs, especially in our climates, vary constantly because they depend on internal and external heat inputs and occupancy rates. Therefore, a pre-adjustment of the flow rates based on the theoretical requirements of the building is not necessary.

-To reduce electricity consumption, it is recommended to use a variable speed circulator that will maintain constant pressure on the manifold, regardless of the heat demands and therefore the flow rates needed.

7. OPAL-SYSTEMS PRINCIPLE OF SIZING AND ADJUSTMENTS.

- The manifold supply pipe diameters must be sufficient to limit pressure losses resulting in unacceptable pressure drops to the manifold as demands increase. The sizing of these supply pipes must be established on the basis of a water flow of 2 litres per minute per connected pipe, a maximum line pressure loss of 100 to 120 Pa/m and a maximum load pressure loss of 30,000 Pa.

- The circulator must be able to circulate 2 litres per minute per connected pipe, with maximum pressure losses within the OPAL underfloor heating pipes and the manifold being around 15,000 Pa.

3. TEMPERATURES

The temperature of the water generated by the heat-generating machine must be sufficient to offset the losses of the most demanding room, also taking into account the nature and thickness of its finish flooring and the comfort requirement for that room.

Thanks to the heating curve and an external temperature sensor, this temperature will be adjusted to the weather conditions. The theoretical value of the water temperature for the OPAL-Systems underfloor heat emitter can be established using the emission diagram established according to the EN 1264 standard. Given these data, an accurate calculation can be provided.

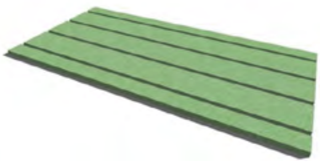
8. BOX-OUT SPACES TO SET ASIDE

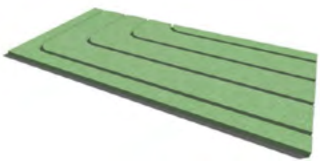
The box-out spaces to be set aside will be confirmed in a diagram taking into account the type, thickness and method of securing the finish flooring.
For bonded finish flooring, the box-out must be =~ 22 mm. For unbonded finish flooring, the box-out must be =~ 19 mm.

9. INSTALLATION

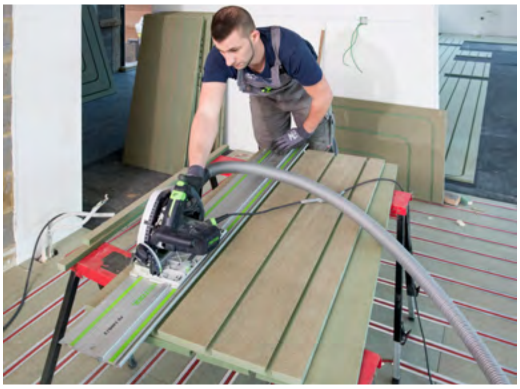
The substrate of the OPAL boards must be stable, sound, flat and thermally insulated in accordance with the legislation in force. The OPAL system boards are laid out on the ground to form a bifilar spiral circuit according to the layout plan provided.

9.1. THE BOARDS

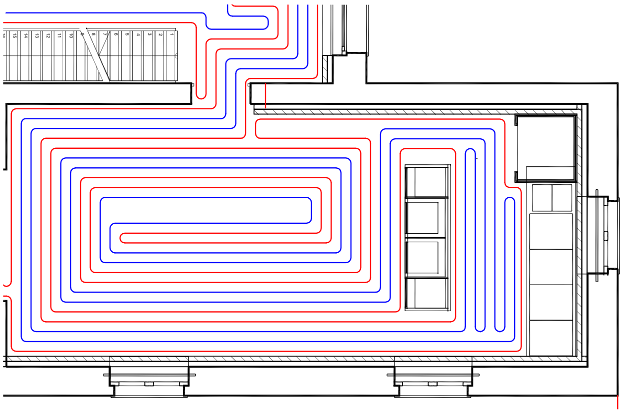




In order to cover all kinds of room geometries, several (11) board models have been pre-manufactured. They will be cut to length on the site to fit with the dimensions and geometry of the heating areas (see examples on photos below).

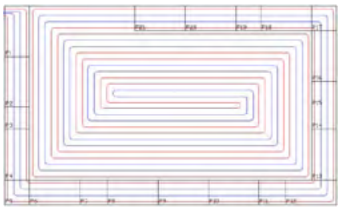


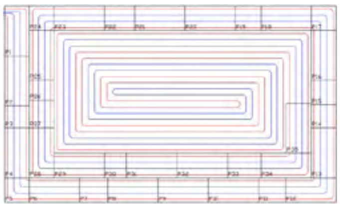
Depending on the nature of the substrate, the boards can be secured with screws, clips or glue. It will also be possible to leave the boards floating entirely on the substrate.

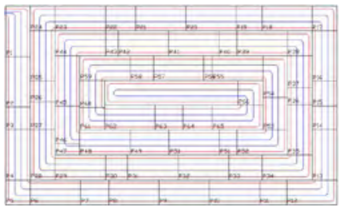


•To tell them apart on the diagram, different colours have been chosen for the pipes of the same thermal area.

•The boards are laid out along the edge of the room starting with the supply corner, according to the lay-out plan provided. The direction of fitting the boards must be that of the pipes (clockwise or coun-ter-clockwise).







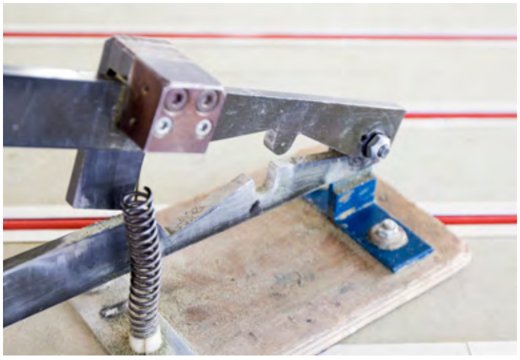
The board dimensions are 220 x 600 x 18 mm. The off-cuts created by the cuts along one side are used for the following side.

The boards are laid out so as to ensure continuity of the groove which receives the pipe and which extends to the centre of the room before returning to the supply point. The central part of the room requires additional cuts.

It is sometimes also necessary to fill certain areas with solid boards (without pipes), 18 mm thick, possibly covered by aluminium mesh. For example, under kitchen units.

9.2. THE DIFFUSER

The diffuser (omega) is placed over the groove and inserted by hand or foot. The 1-metre long profiles are placed in sequence along the straight parts of the groove.

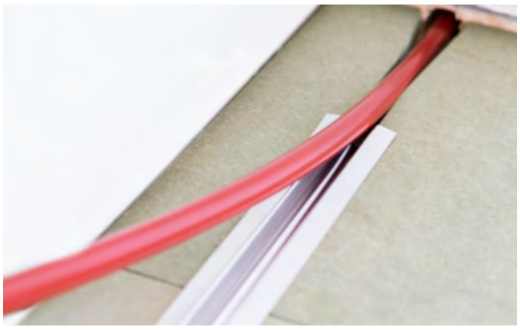


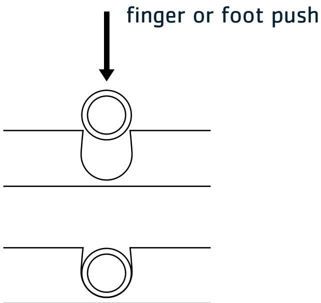
A small gap (~ 1 mm) is kept between them to prevent them from overlapping.
If necessary, they are cut to length using a special cutter to avoid creating any sharp edges that could damage the pipes.

9.3. THE PIPE

The groove can be cleaned with a brush dipped in soapy water. This prevents objects or debris that can damage the pipe from being left in the bottom of the groove. The soap is also a lubricant facilitating insertion of the tube.

The pipe is then placed over the omega diffuser and forced firmly inside using a hand, foot or a heavy roller, to the bottom of the groove. After insertion, the upper part of the pipe must not exceed the level of the omega diffuser.





In order to limit the maximum length of the pipes to a hundred metres, several pipes are used in parallel when the surface of the thermal area to be heated is large. This helps limit the drop in water temperature between the feed and the return flows and therefore allows operation with less hot water. Pressure losses are also reduced.

With a uniform pitch of 15 cm, the length of pipe needed to cover a square metre is 6.66 m. Therefore, the maximum coverage for a single pipe is ~ 100 / 6.66 =~ 15 m^2.

As shown in the photo opposite, when multiple pipes in parallel supply the same thermal area, their ends are connected to the manifold by alternating the feed and return flows and by nesting the pipes.

This allows the surface temperature to be uniform and guarantees equal lengths (within a few metres) for the various pipes.

Since the pipes are of the same length, it is not necessary to balance them with the manifold flow-control valves.

This installation principle is also true for the layout plan.

9.3.1. Filling with water and tightness test of the pipes

Mesh (see below) and finish flooring installation must be carried out after a water tightness test of the underfloor heating pipes. The pipes are left under pressure for one day.

The air present in each pipe is totally removed by an abundant flow of running water. The water is topped up by the collector, one end of which is discharged (sewer). After the test, the working pressure for the water of the underfloor heating is reduced to =~1.5 bars.

9.4. THE MESH

The aluminium mesh is supplied in rolls 25 m long by one metre wide. It is secured to the wooden substrate with staples placed every ~ 15 x 15 cm to ensure the surface is completely flat for installation of the finish flooring.

If necessary, the mesh should be cut to suit the geometry of the room. The mesh strips will be laid side by side, avoiding overlaps to ensure flatness.

9.5. INSTALLATION OF THE FINISH FLOORING

9.5.1. Bonded finish flooring

In order to ensure the best possible transfer of heat to the finish flooring, it must be bonded over its entire surface. Under no circumstances may tiles be laid using dabs of glue.

The glue mortar used must comply with the European "Flexible mortar" regulation and meet the deformability requirements defined by classes S1 or S2

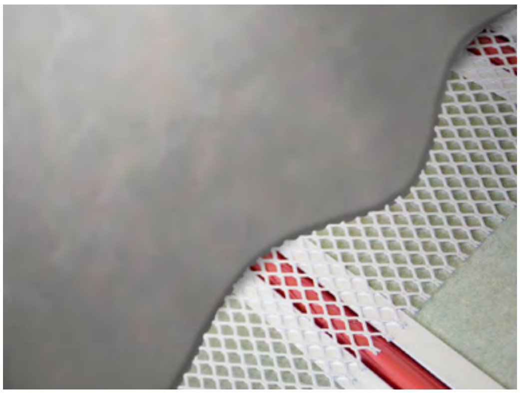
Tiling

Wood flooring

For glued wood flooring, the recommendations of wood flooring specialists must be followed with respect to the installation conditions (humidity), maximum width and thickness of the boards, wood species, etc. suitable for underfloor heating.

9.5.2. Poured finish coat flooring

The poured coating will be applied directly to the mesh and will completely cover it. To reduce the amount of material needed, gaps along the walls can be plugged with a more viscous product.



Decorative poured flooring

Self-levelling fibred compound that can, for example, form the substrate for laying linoleum or carpet

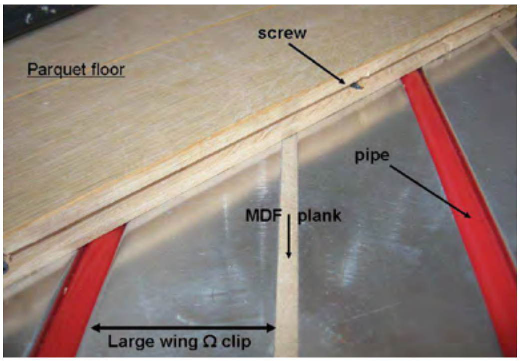
9.5.3. Floating finish flooring (floating floor)

The floor can be laid on the emitter. The "noise-cancelling" sheet recommended by the supplier reduces the cracking noise of the boards that rotate slightly in their interlocking system.

The boards can also be glued on their ends.

The recommendations of wood flooring specialists must be followed with respect to the installation conditions (humidity), maximum width and thickness of the boards, wood species, etc. suitable for underfloor heating.

9.5.4. Nailed or screwed finish flooring (wood floor)



Nails or screws can easily be sunk into the wide diffusers. The recommendations of the wood floor specialists must be followed with respect to the installation conditions (humidity), maximum width and thickness of the boards, wood species, etc. suitable for underfloor heating.

10. SUBSTRUCTURES

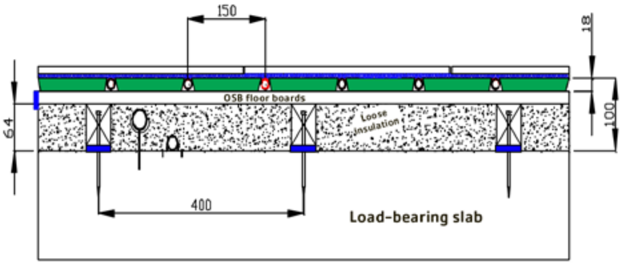
The underfloor heating boards must be laid on a stable, flat, thermally insulated (and possibly acoustically) substrate.

Several solutions exist. The choice will depend on the constraints of volume, level of insulation, type of insulation, cost, installation time, etc.

EXAMPLES:

10.1. ON A NEW FLOOR

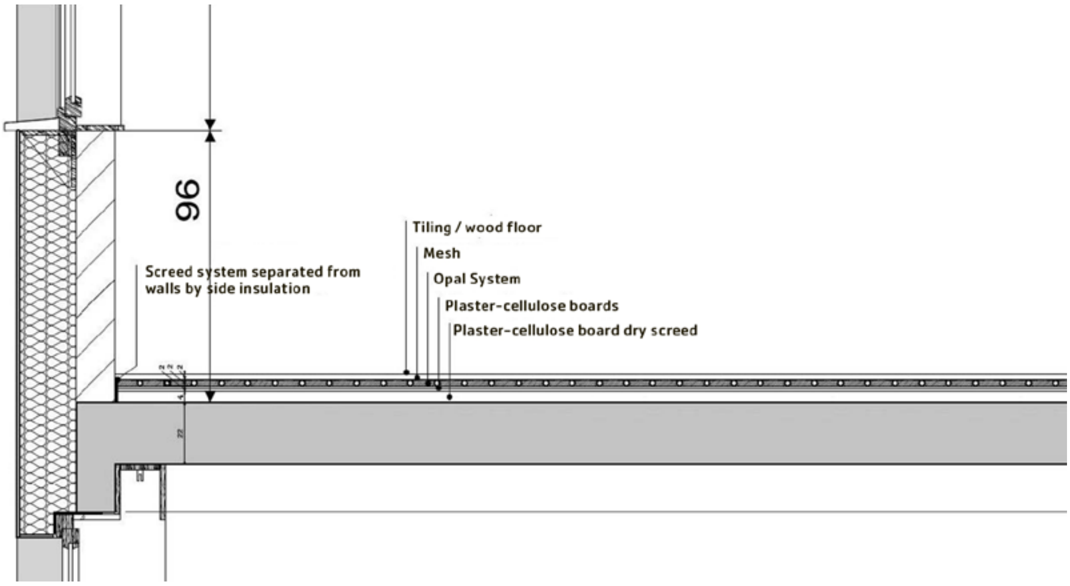
- By stapling on insulated joists covered with load-bearing particle boards (OSB, SB7, etc.)



- By gluing to a damp screed

10. SUBSTRUCTURES

- Dry screed



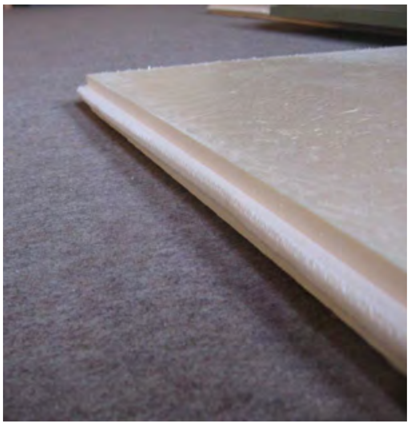
- On an insulating screed (expanded polystyrene beads mixed with cement) and covered with a self-levelling compound

10.2. ON AN EXISTING FLOOR

- Old wood floor + insulating boards (wood wool, PU, PIR, etc.)

- Insufflation-insulated old wood floor

- Floating or glued to old tiling or carpet + insulating boards



10.3. ON WALLS (WALK-IN SHOWER)

10.4. INTEGRATION OF STAIRS, SPOTLIGHTS, ELECTRICAL SOCKETS, DRAINAGE AND WATER PIPES, ETC...

It is necessary and sufficient that these box-out spaces have been clearly marked on the ground before installation of the underfloor heating.

11. CALCULATION OF EMISSIVE POWER

The calculation of nominal heat emissions is based on the CSTC technical Information note No. 170.

Emissive power (W/m²):
through the floor:
- 8.92 (TS,m – Tamb)1,1 in heating mode;
- 7 (TS,m – Tamb) in cooling mode;

through the ceiling:
- 8.92 (TS,m – Tamb)1,1 in cooling mode;
- 6 (TS,m – Tamb) in heating mode;

through vertical walls:
- 8 (TS,m – Tamb)

With
- TS,m = the average temperature of the floor surface;
- Tamb = the room's ambient operating temperature;

Since the nominal heat requirements of all the thermal areas are known, the temperature to be reached for the top facing of the finish flooring can be calculated for each area, taking into account the available floor surface for heating and the comfort setpoint.

Once these surface temperatures have been determined, the water flow rates and feed inflow temperatures can, for each thermal area, be calculated according to the nature and thickness of the finish flooring. Downward losses are taken into account in the calculation. These depend on the thermal resistance of the layers under the underfloor heating pipes.

In heating mode, the surface temperatures will not exceed the limit values set by the standards:
- peripheral areas: 35°C;
- central areas of living rooms: 29°C;
- central areas of bathrooms: 33°C;

The highest inflow feed water temperature required for a given thermal area will be that of the entire installation. The other areas will operate with the same inflow feed water temperature, but with reduced flow rates.

The flows, area by area, will be automatically adjusted by the control, according to the specific needs of each of them.

These calculations are summarised as a spreadsheet that can be used directly.

12. HEAT SOURCES

The emitter can be connected to any heat production system:

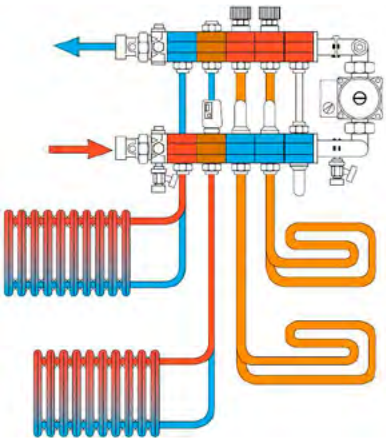
12.1. HEAT GENERATING MACHINES

Gas, fuel oil, wood, electric, solar boiler, etc.

12.2. HEAT PUMP

Air-water, ground (vertical) – Water, Ground (horizontal) – Water, Water-Water,...

12.3. COMBINATION WITH OTHER HIGHER TEMPERATURE EMISSIVE SYSTEMS



A single collector to supply high-temperature water to radiators and to control the water in the circuits of a low temperature heated floor

The use of underfloor heating can be combined with that of other emissive systems (radiators). In this case, a system of mixing between the hottest water from the boiler and that of the underfloor heating return produces water at a low temperature suitable for the underfloor heating.

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