

INFRA AQUA DESIGN

Hot water radiant panels



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CLIMATE TECHNOLOGY
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What is radiant heating?

Radiant heating is based on the principle of the heat transfer of a warm body to a body with a lower temperature by means of electromagnetic wave energy. This electromagnetic wave is not hindered by air, radiates walls, floor and other bodies in the specific room. These items absorb the radiation energy and then pass the heat on to the heat air stream.

This produces a convective flow of slowly rising warm air and colder air falling again that blend (induction).

The heating of the air in the space takes place substantially by this convective air flow from the heated floor and walls.

Heating a room by means of radiant panels always causes the floor temperature to be a few degrees higher than the room air temperature which in turn is experienced as very comfortable. Even directly under the radiation panel, the vertical temperature gradient is very low.

As the roof is often the largest surface that is directly in contact with the outside air, with air heating more energy will be lost by heating this cold surface (see graph "Temperature per meter height" on page 8).

Although this can be overcome by a high circulation times in space which, however, requires extra energy, during which a high air displacement occurs.

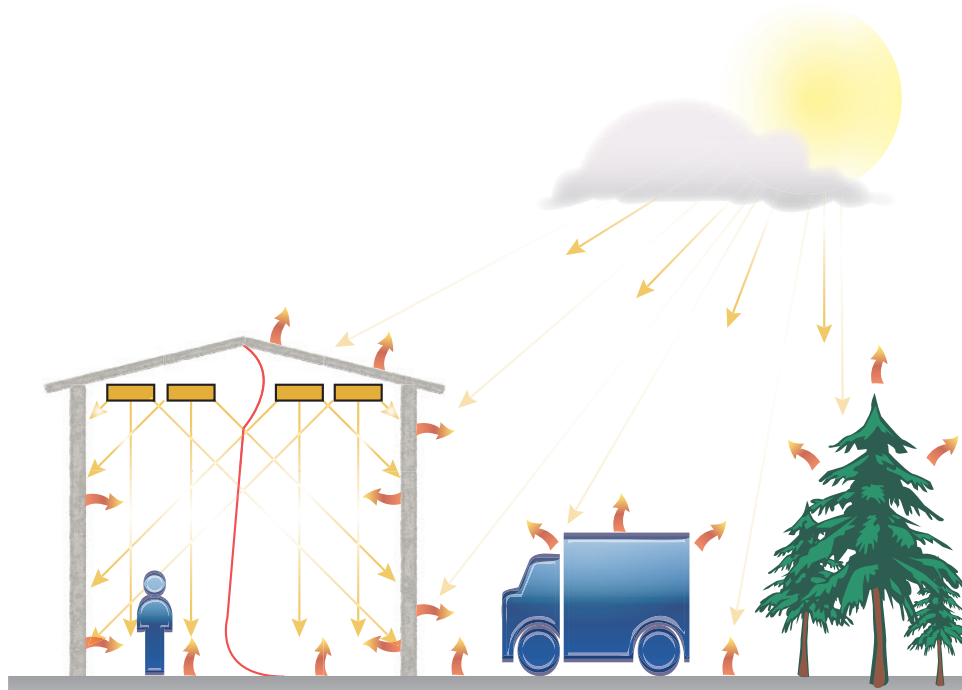
Consequence: drafts and dust displacement. Floor and walls remain cold!

COMFORT

When our body gives more heat to its environment than it produces, we experience this as uncomfortable.

The ideal method to heat cold surfaces is by means of radiant panels mounted on the ceiling which transfer their heat mainly through radiation.

Persons who are radiated in a room experience less heat loss and therefore greater comfort. As a result, the room air temperature may be set a few degrees lower. This way, in addition to more comfort energy saving can be realized.



Radiant heating

WHY RADIANT HEATING?

Radiant heating has been used for decades in areas ranging from 2.5 to 25 meters suspension height. Radiant heating is installed at places where it costs nothing, namely on the ceiling. Radiant heating is relatively quickly assembled, has no maintenance, produces no noise and has a very long life.

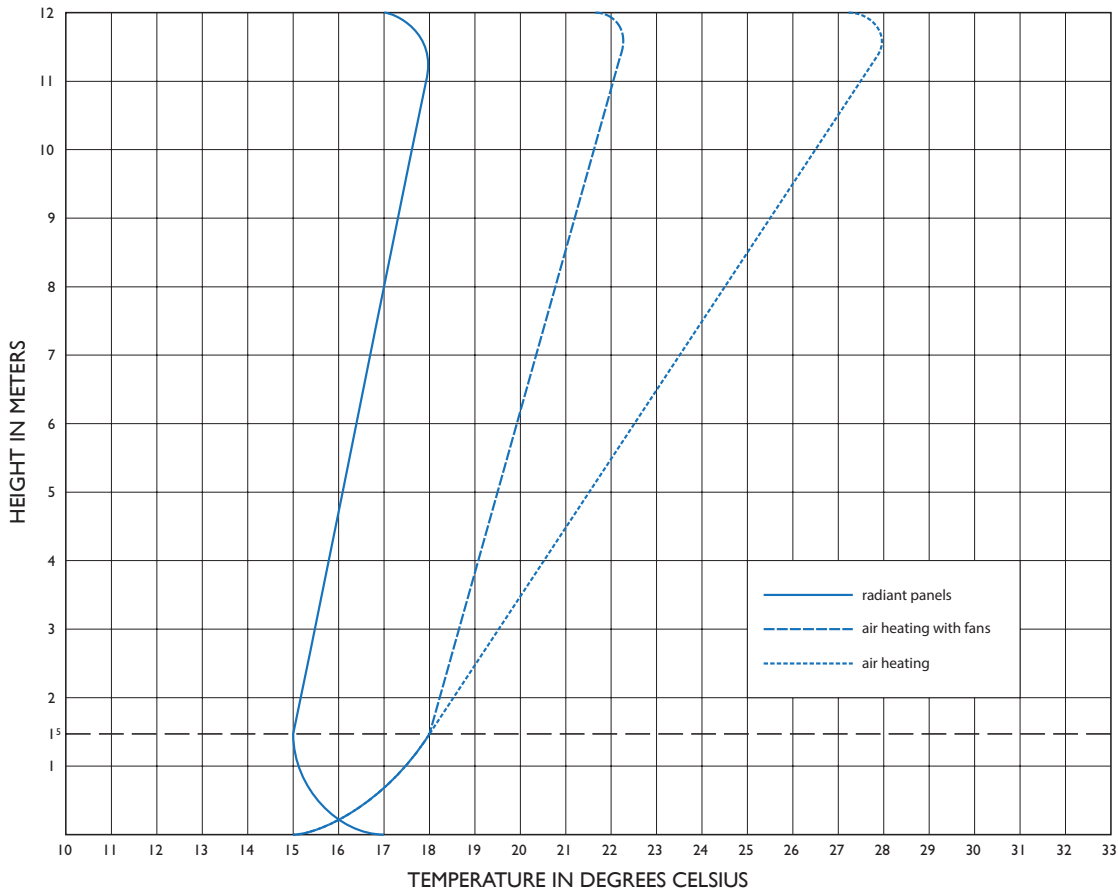
ZONE OR LOCALISED HEATING

Radiant heating is also ideal for zone or local heating. Only the area to be heated is radiated. As a result, the energy costs are limited to a minimum.

SYSTEM BENEFITS

- Fast controllability by a low water content.
- Uniform temperature distribution all over the horizontal area.
- Very low vertical temperature gradient.
- Zone or local heating is possible.
- Still air layer, no dust or drafts.
- Room temperature is 3°C lower than heating by radiators or air heating.
- 25-30% energy savings compared to conventional air heating.
- 15% less full load hours.
- Very long life.
- Completely maintenance free.
- Great comfort by direct radiation.
- Heated floor.
- Space saving.
- Silent.
- Can be applied everywhere due to unobtrusive design.

GRAPH (the difference in the vertical temperature gradient for radiant heating and air heating)



Mark radiant panel

Mark radiant panel consists of a number of hot water tubes. When the water reaches the appropriate flow, turbulence is created which in turn provides an optimum heat transfer from water to metal.

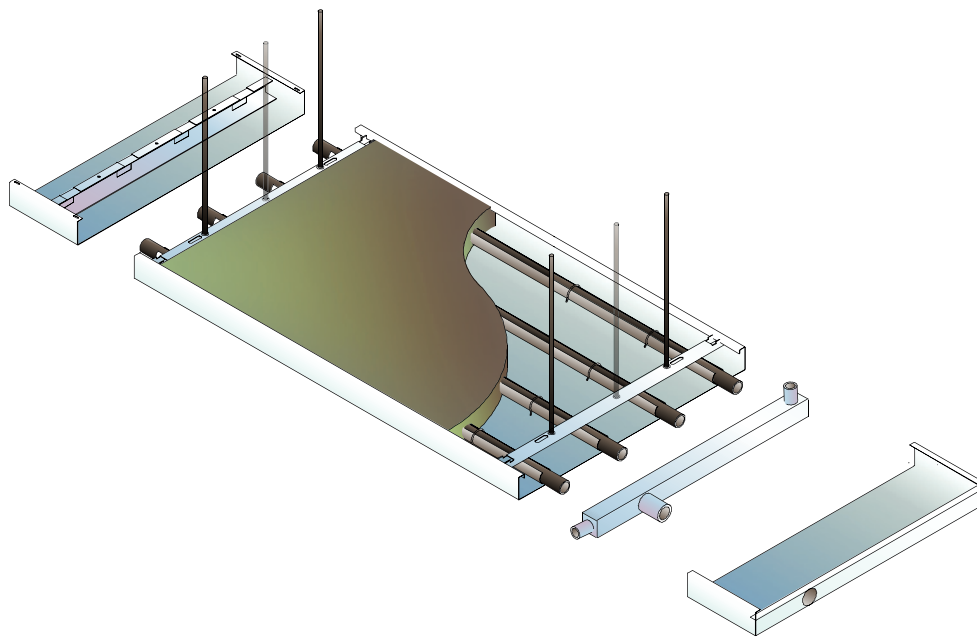
The hot water tube bundle, composed of tubes with a diameter of 28 mm (untreated or galvanized) is surrounded by profiled aluminium plates for more than 80% and reinforced by spring clips.

A multi-angle conversion gives a very large stiffness to the angle profiles of the panel.

A U profile welded to the register enables a stable suspension. To achieve this, there are M8 blind rivet nuts applied in the U profile.

To prevent heat loss to the upper side, the panels are equipped with a 40 mm mineral wool with double reinforced aluminium foil insulation. (Fire Class A1/A2).

The cover plates and end caps ensure a neat finish.



THE ADVANTAGES OF THE MARK RADIANT PANEL

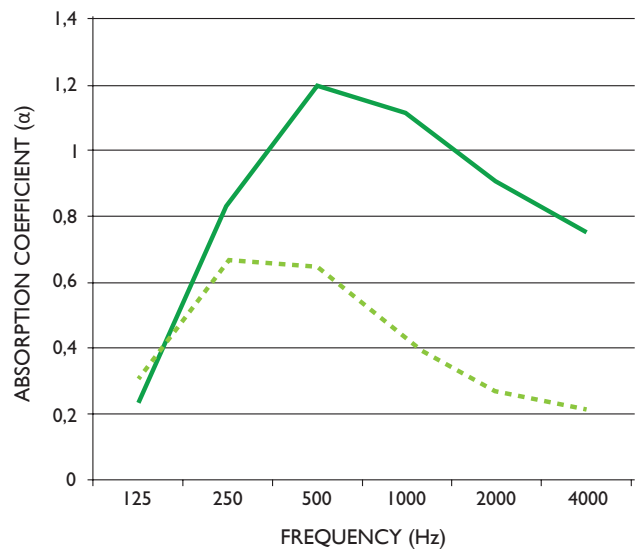
- High output of the panel, obtained by 80% metal contact of tube/aluminium fin.
- The use of aluminium, a very good thermal conductivity.
- High insulation value by applying 40 mm mineral wool
- Pre-assembled insulation.
- Aesthetically beautiful and entirely flat panel.
- Very tight and therefore perfectly integrated into a (suspended) ceiling grid, e.g. width 590 mm.
- Standard colour RAL 9010 with scratchproof paint, optionally available in any RAL colour.
- Low weight
- Wide standard range of 6 types, lengths depending on project.
- Panels are supplied complete with an assembled insulation and welded collectors.
- Collectors are standardly primed.
- Zinc plating of the registers when used in damp spaces. (optional)
- Mark provides complete engineering.

APPLICATION AREAS

- Auto showrooms
- Furniture showrooms
- DIY-buildings
- Schools
- Sports-/Tennis halls
- Social (sheltered) workshops
- Bakeries
- Printing / Press rooms
- Paints factories
- Machine factories
- Fire stations
- Police stations
- Production halls
- Hospitals and nursing homes
- Logistic halls
- Areas with a danger of gas and/or explosion. Directive 94/9/EC (Atex 95).

Optional: acoustic panels

The Mark Infra Aqua Design radiant panels can optionally be supplied in a perforated version for optimum room damping.



- Mark Infra Aqua Design radiant panel
- Mark Infra Aqua Design radiant panel with perforation

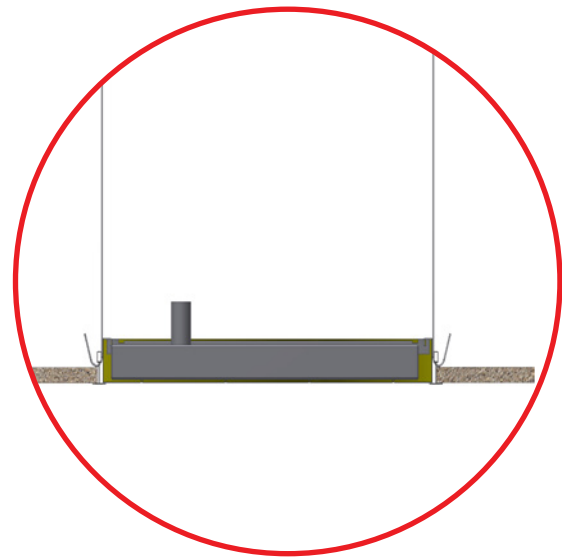
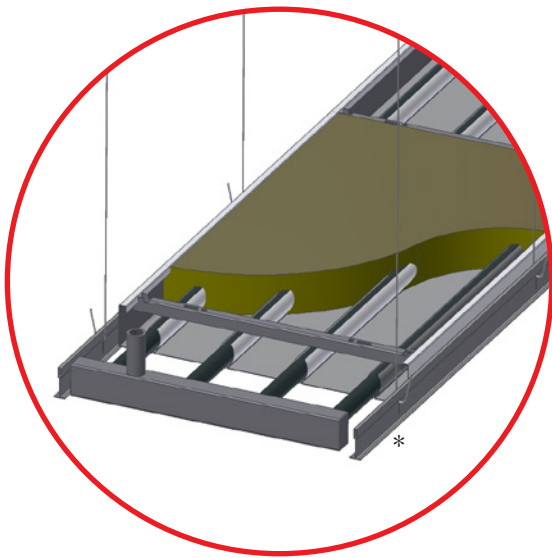


Application in a (suspended) ceiling grid

The radiant panel is perfectly integrated into a (suspended) ceiling grid. The flat aluminium surface with a fine line pattern gives an aesthetic effect that fits into any ceiling. In terms of sizing the panel type 600-4 with a width of 590 mm is an obvious choice. For higher output, also the type 1200-8 (1190 mm wide) can be applied. In addition to the standard ceiling sizes (590, 1190, 1790, 2390 mm etc.) the panels are also available in intermediate sizes for customization.

FEATURES

- Any length size is possible
- Top connection
- Aluminium panel with low weight
- High heat output
- Mineral wool (GLW) insulation

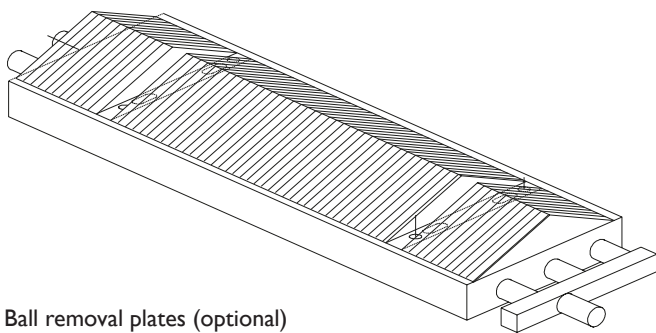


* Image is shown without cover.

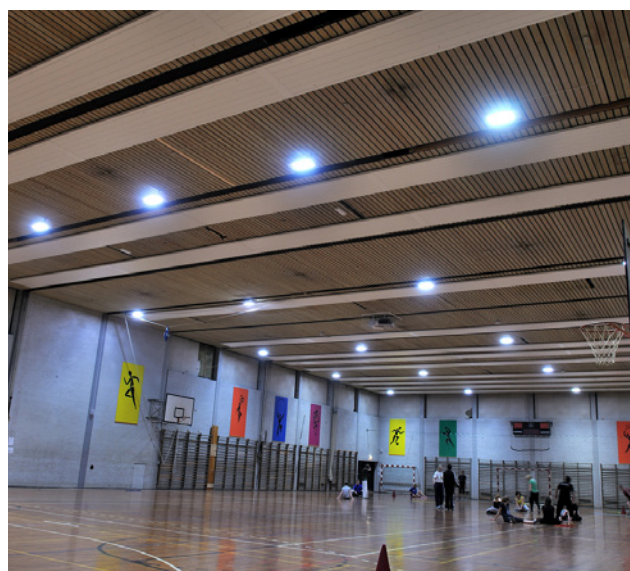


Application in a sports hall

The most optimal way of heating a sports hall or gymnasium is by means of water based radiant panels. Spaces can be heated quickly and separately without the displacement of air and the associated noise. In addition to this, the panels on the ceiling do not form a danger to the users of the space.

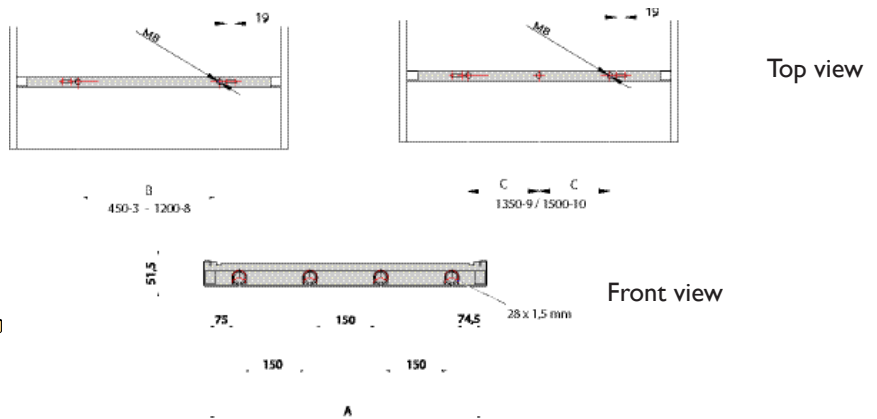
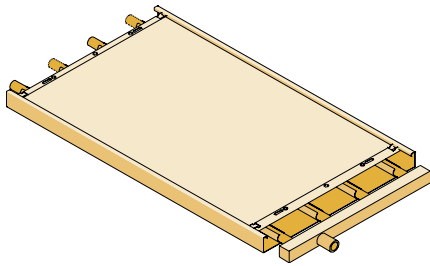


Ball removal plates (optional)

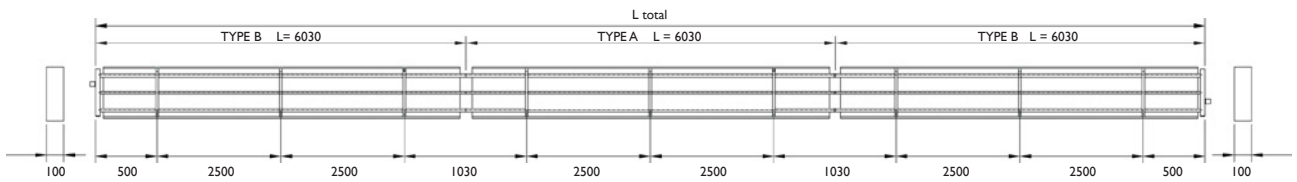


Technical specifications

DIMENSIONS

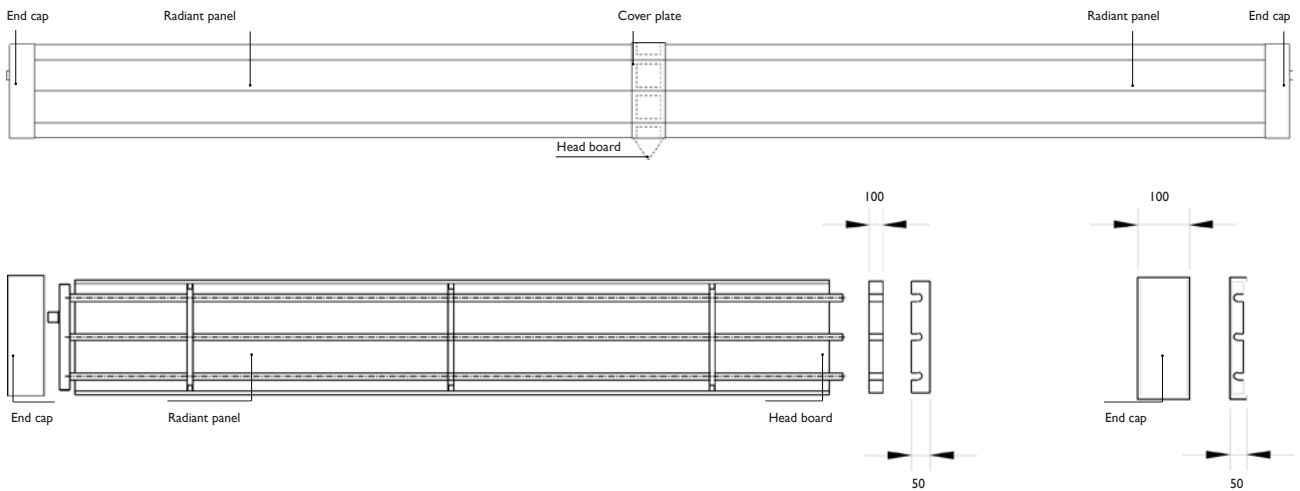


Type	450-3	600-4	750-5	900-6	1050-7	1200-8	1350-9	1500-10
Width = A	440	590	740	890	1040	1190	1340	1490
B/C in mm	200	300	450	600	750	600	375	450
Mounting points (6m)	3x2	3x2	3x2	3x2	3x2	3x2	3x3	3x3
D (number of tubes)	3	4	5	6	7	8	9	10

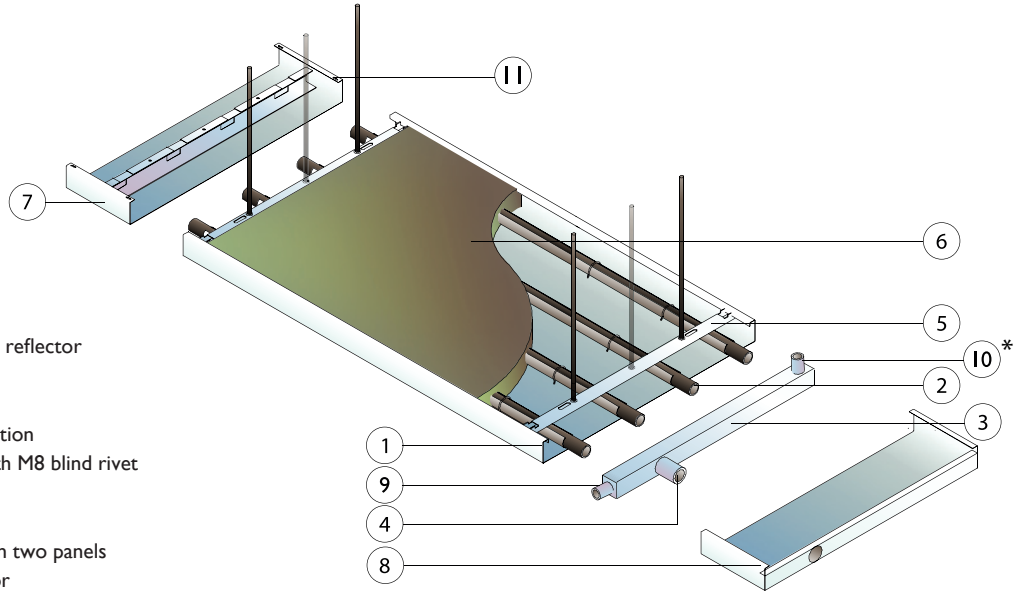


Standard L = 3000, 4000, 5000 en 6000 mm.
 Size in between = price of next higher standard size.

Suspension dimensions are variable, maximum 3 per 6 meter panel. There is a surcharge for multiple mounting profiles. The maximum spacing of supporting profiles is 2500 mm.



DETAILED VIEW / WEIGHT



- 1 = Aluminium radiation reflector
- 2 = Water based tube
- 3 = Collector
- 4 = Water sided connection
- 5 = Mounting profile with M8 blind rivet nuts
- 6 = Insulation
- 7 = Cover plate between two panels
- 8 = Cover plate collector
- 9 = Drain point (optional)
- 10 = Air point * (optional)
- 11 = Slit hole for tapping screws

Type		450-3	600-4	750-5	900-6	1050-7	1200-8	1350-9	1500-10
Heat output 15°C (90/70°C) room temperature	W/m	300	377	453	529	608	686	764	842
Water content	kg/m	1,47	1,96	2,45	2,94	3,43	3,92	4,41	4,90
Panel weight (filled)	kg/m	6,24	8,49	10,55	12,82	14,67	16,73	18,79	20,85
Weight collector (filled)	kg/m	1,55	2,13	2,70	3,28	3,86	4,44	5,01	5,58

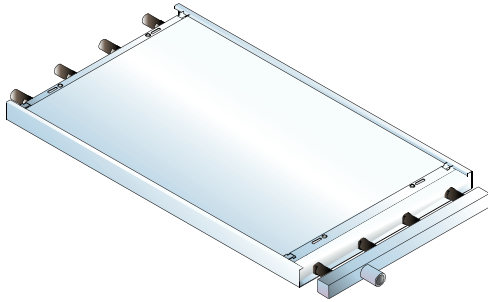
* The air point is to be placed at the highest point of the installation.



HEAT OUTPUT

RADIANT PANEL, TYPE 450-3 to 1500-10

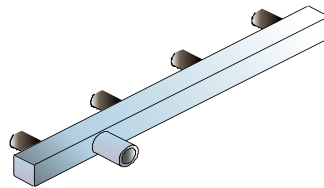
Heat output table in W/m^l, in accordance with EN 14037 1-3



K	450-3	600-4	750-5	900-6	1050-7	1200-8	1350-9	1500-10
115	578	723	868	1011	1162	1313	1465	1618
110	549	687	825	961	1104	1248	1392	1537
105	521	652	782	911	1047	1183	1320	1457
100	492	616	739	862	990	1119	1248	1378
95	464	581	697	813	934	1056	1177	1299
90	436	546	656	765	878	992	1106	1221
85	408	512	614	717	823	930	1036	1144
80	381	477	573	669	768	868	967	1067
75	354	443	533	622	714	807	899	991
70	327	410	493	576	661	746	831	916
69	322	403	485	566	650	734	817	901
68	316	397	477	557	639	722	804	887
67	311	390	469	548	629	710	791	872
66	306	383	461	539	618	698	777	857
65	300	377	453	529	608	686	764	842
64	295	370	445	520	597	674	751	828
63	290	364	438	511	587	662	737	813
62	285	357	430	502	576	650	724	798
61	279	351	422	493	566	638	711	784
60	274	344	414	484	555	627	698	769
59	269	338	406	475	545	615	685	755
58	264	331	399	466	534	603	671	740
57	259	325	391	457	524	591	658	726
56	254	318	383	448	514	580	645	711
55	248	312	375	439	503	568	632	697
54	243	306	368	430	493	556	619	683
53	238	299	360	421	483	545	607	668
52	233	293	353	412	473	533	594	654
51	228	287	345	403	463	522	581	640
50	223	280	337	395	453	510	568	626
49	218	274	330	386	442	499	555	612
48	213	268	322	377	432	488	543	598
47	208	261	315	368	422	476	530	584
46	203	255	307	360	412	465	517	570
45	198	249	300	351	402	454	505	556
44	193	243	293	342	392	442	492	542
43	188	237	285	334	383	431	480	528
42	183	231	278	325	373	420	467	515
41	178	224	270	317	363	409	455	501
40	174	218	263	308	353	398	443	487
39	169	212	256	300	343	387	430	474
38	164	206	249	291	334	376	418	460
37	159	200	241	283	324	365	406	447
36	154	194	234	274	314	354	394	433
35	150	188	227	266	305	343	382	420
30	126	159	192	225	257	290	322	354
25	103	130	157	185	211	238	264	290
20	81	102	124	146	166	187	208	229
15	60	76	92	108	123	139	154	169

COLLECTOR TYPE 450-3 to 1500-10

Heat output table in W/m^l, in accordance with EN 14037 1-3 per 2 collectors



K	450-3	600-4	750-5	900-6	1050-7	1200-8	1350-9	1500-10
115	88	113	138	164	184	203	223	243
110	84	107	131	155	174	193	212	230
105	79	101	124	147	164	182	200	218
100	75	96	117	138	155	172	189	205
95	70	90	110	130	146	161	177	193
90	66	84	103	122	136	151	166	181
85	62	79	96	114	127	141	155	169
80	58	73	89	106	118	131	144	157
75	53	68	83	98	110	121	133	145
70	49	63	76	90	101	112	123	134
69	49	62	75	88	99	110	121	131
68	48	61	74	87	97	108	118	129
67	47	60	72	85	96	106	116	127
66	46	59	71	84	94	104	114	124
65	45	58	70	82	92	102	112	122
64	44	57	69	81	91	100	110	120
63	44	55	67	79	89	98	108	118
62	43	54	66	78	87	97	106	115
61	42	53	65	76	85	95	104	113
60	41	52	64	75	84	93	102	111
59	40	51	62	73	82	91	100	109
58	40	50	61	72	81	89	98	107
57	39	49	60	70	79	87	96	104
56	38	48	59	69	77	86	94	102
55	37	47	57	67	76	84	92	100
54	37	46	56	66	74	82	90	98
53	36	45	55	64	72	80	88	96
52	35	44	54	63	71	78	86	94
51	34	43	52	62	69	77	84	91
50	33	42	51	60	67	75	82	89
49	33	41	50	59	66	73	80	87
48	32	40	49	57	64	71	78	85
47	31	39	48	56	63	69	76	83
46	30	38	47	55	61	68	74	81
45	30	38	45	53	60	66	72	79
44	29	37	44	52	58	64	71	77
43	28	36	43	50	56	63	69	75
42	27	35	42	49	55	61	67	73
41	27	34	41	48	53	59	65	71
40	26	33	40	46	52	57	63	69
39	25	32	38	45	50	56	61	67
38	24	31	37	44	49	54	59	65
37	24	30	36	42	47	52	58	63
36	23	29	35	41	46	51	56	61
35	22	28	34	40	44	49	54	59
30	19	24	28	33	37	41	45	49
25	15	19	23	27	30	33	37	40
20	12	15	18	21	23	26	28	31
15	9	11	13	15	17	19	21	22

K = Average water temperature - room temperature. Values at a mass flow of 0.04 litres per second / pipe.

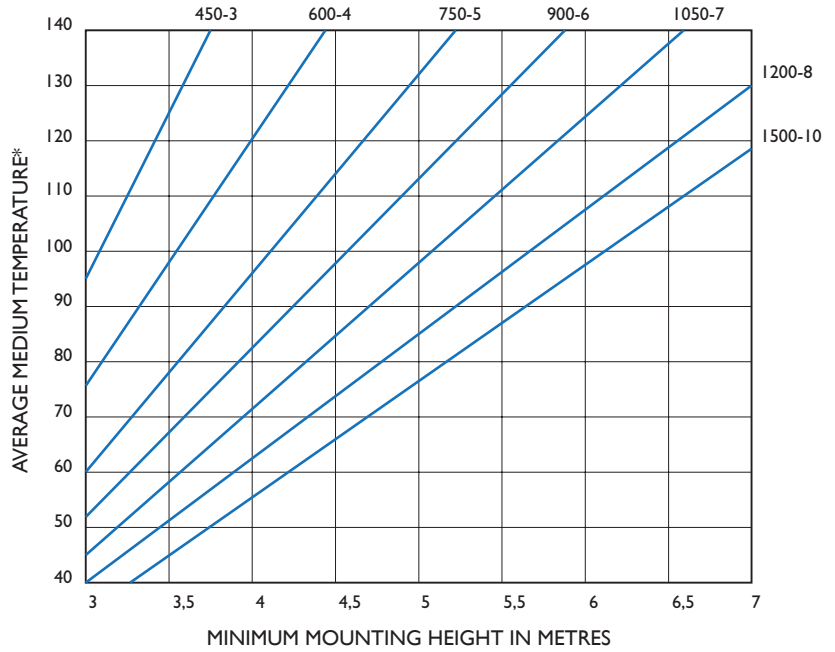
MINIMUM MOUNTING HEIGHT WITH A LONG RESIDING TIME AND A LOW ACTIVITY LEVEL

The prevention of a too high radiation temperature in low areas:

- By reducing medium temperature.
- By applying narrow panel lengths.

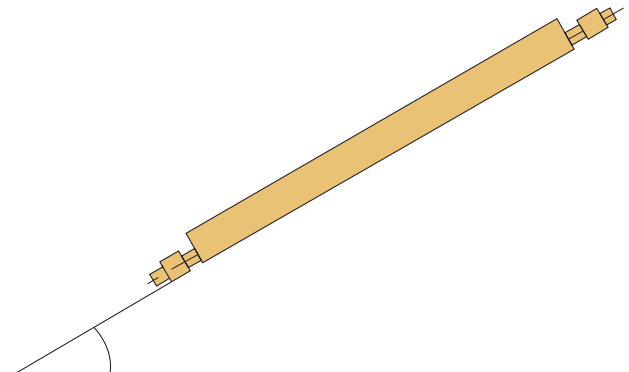
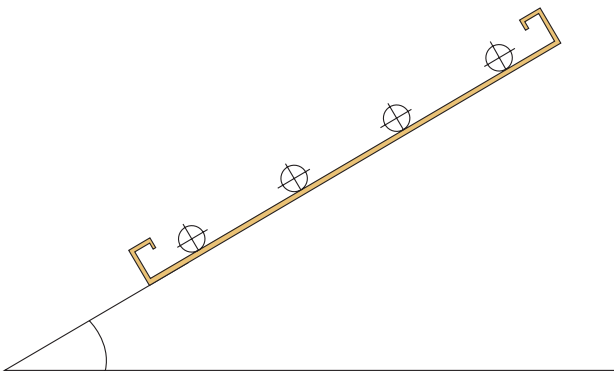
$$* \frac{(T_a + T_r)}{2}$$

- T_a = Water temperature supply
- T_r = Water temperature return



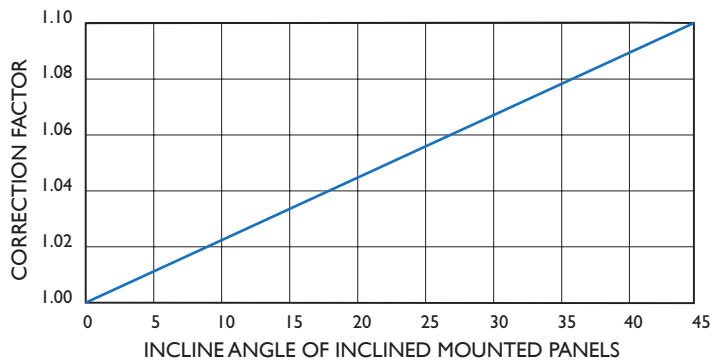
When mounting in suspended (lowered) ceiling, the output is reduced by 8%.

RADIANT PANELS MOUNTED IN AN INCLINED ROOF



The total output when mounted under an inclined roof is increased by the increasing convection. The correction factor can be determined with the graph on the right.

Total output = output per linear metres x correction factor

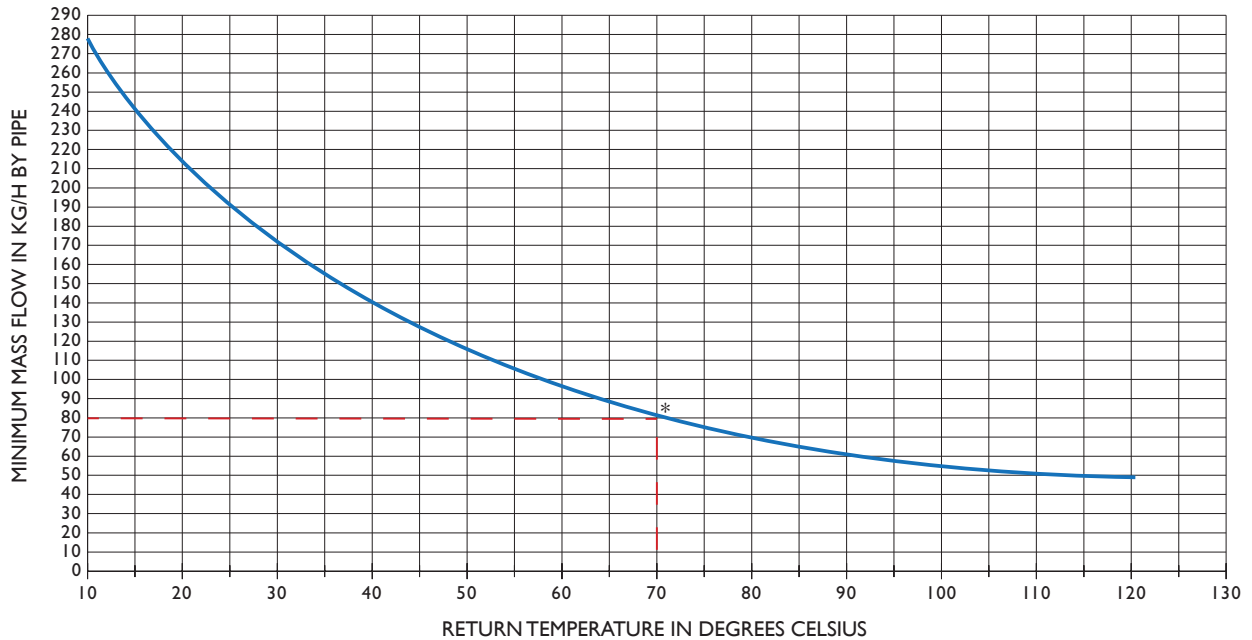


RELATIONSHIP BETWEEN THE MINIMUM MASS FLOW AND RETURN TEMPERATURE

The graph below shows the relationship between the minimum mass flow and the return temperature. The minimum mass flow is required to obtain a turbulent flow in the pipes. Only then the heat output can be realized. In case this mass flow rate is too low (often caused by short panel lengths), a laminar flow is created which in turn results in a strong decline of the heat output.

A too low mass flow in the tubes can be prevented by:

- Decreasing the difference between the flow and return temperature.
- Applying separation plates in the collector.
- Connecting multiple panel lengths in series.



* Example calculation on page 19



THE CALCULATION OF PRESSURE LOSSES OF THE MARK RADIATION PANELS

The resistance of the most optimally selected panel is as low as possible and yet mass flow rate is sufficient.

Depending on the type of panel, this is determined by:

- the mass flow of the medium per panel
- the method of connection of the hydraulic system
- the connection diameter

The mass flow per panel is calculated using the output and the difference between the flow and return temperature:

$$M = \frac{P}{C_p \times \Delta t} \quad \text{kg/s or} \quad \frac{P \times 0,86}{\Delta t} \quad \text{kg/h}$$

P = total output of the panel in W.

Δt = total output of the panel in

C_p = specific heat of water $\pm 4200 \text{ J}/(\text{kg}\cdot\text{K})$

The thermal output of the panel can be calculated using the table on page 16. The factor K is defined by:

$$K = \frac{T_a + T_r}{2} - T_u$$

T_a = flow temperature of the water

T_r = return temperature of the water

T_u = room temperature

CALCULATING PRESSURE LOSSES IN REGISTERS, COLLECTORS AND CONNECTIONS

Example 1

Panel type MARK 900-6, L = 30 m
Connection two-sided (mass flow over 6 pipes).

Medium temperature 90/70°C, Room temperature 15°C
Heat output page 16, $K = (90+70)/2 - 15 = 65$

Using $K = 65$: heat output panel = $30 \times 523 = 15690 \text{ W}$, heat output 2 collectors 246 W

Mass flow per panel $(15690+246)/(4200 \times 20) = 0,190 \text{ kg/s} = 683 \text{ kg/h}$. Mass flow per pipe = $683 / 6 = 114 \text{ kg/h}$.

Minimum mass flow page 18: 80 kg/h at a return temperature of 70°C. Conclusion: sufficient.

Pressure loss in the pipes at 114 kg/h, page 20: Δp at 30 meter = 150 Pa

Pressure loss in both collectors at 683 kg/h, page 21: $\Delta p = 2 \times 120 \text{ Pa} = 240 \text{ Pa}$

Total: $150 + 240 = 390 \text{ Pa}$

Example 2

Panel type MARK 900-6, L = 30 m
Connection two-sided (mass flow over 3 pipes).

Medium temperature 90/70°C, Room temperature 15°C
Heat output page 16, $K = (90+70)/2 - 15 = 65$

Using $K = 65$: heat output panel = $30 \times 523 = 15690 \text{ W}$, heat output 2 collectors 246 W

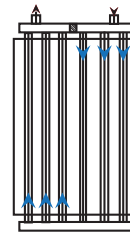
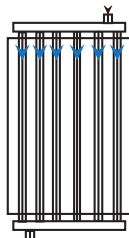
Mass flow per panel $(15690+246)/(4200 \times 20) = 0,190 \text{ kg/s} = 683 \text{ kg/h}$. Mass flow per pipe = $683/3 = 228 \text{ kg/h}$.

Minimum mass flow page 18: 80 kg/h at a return temperature of 70°C. Conclusion: sufficient.

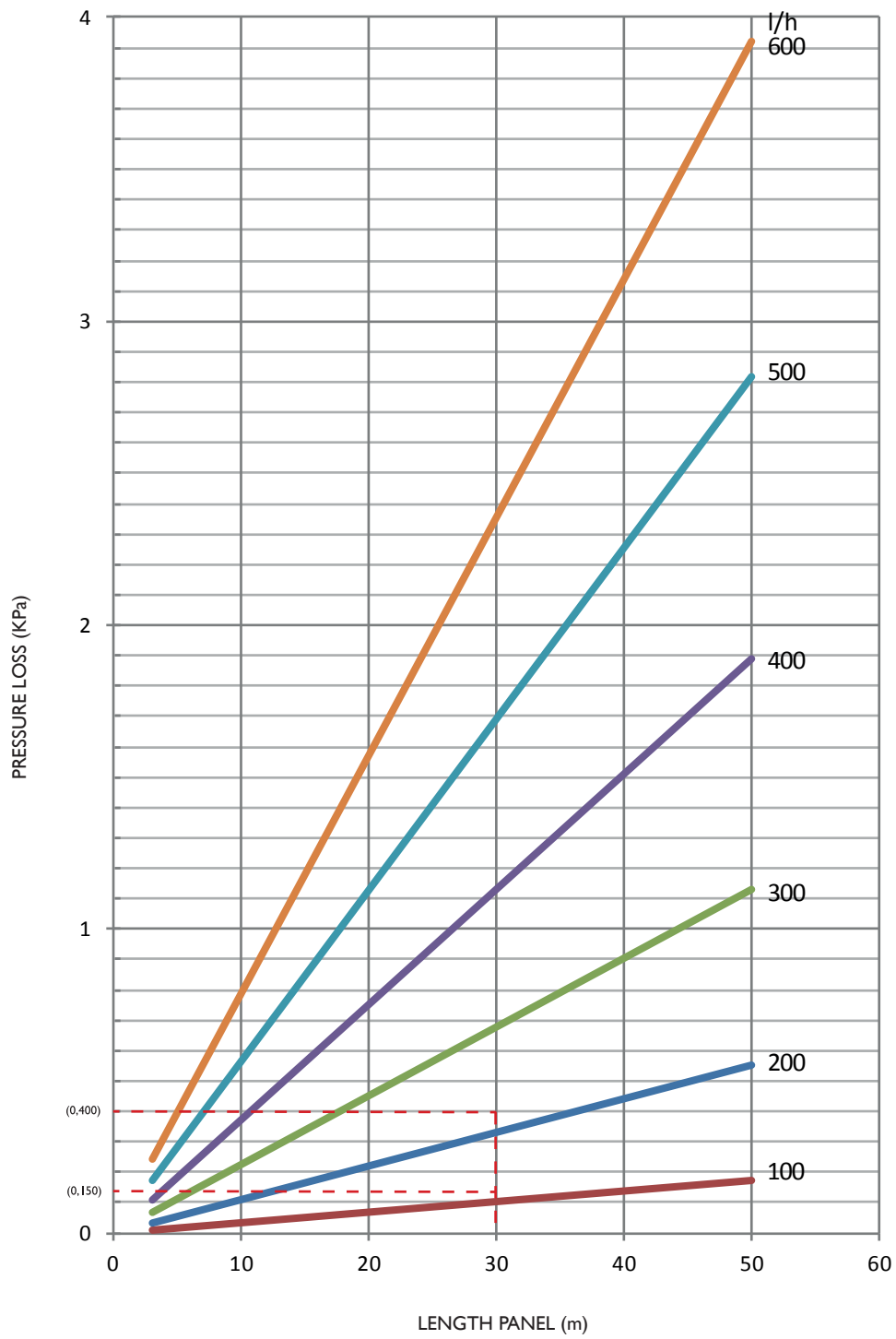
Pressure loss in the pipes at 228 kg/h, page 20: Δp at 30 meter = 400 Pa, Δp at 60 Meter = $2 \times 400 = 800 \text{ Pa}$

Pressure loss in the 3 (!) collectors at 683 kg/h, page 21: $\Delta p = 3 \times 120 = 360 \text{ Pa}$

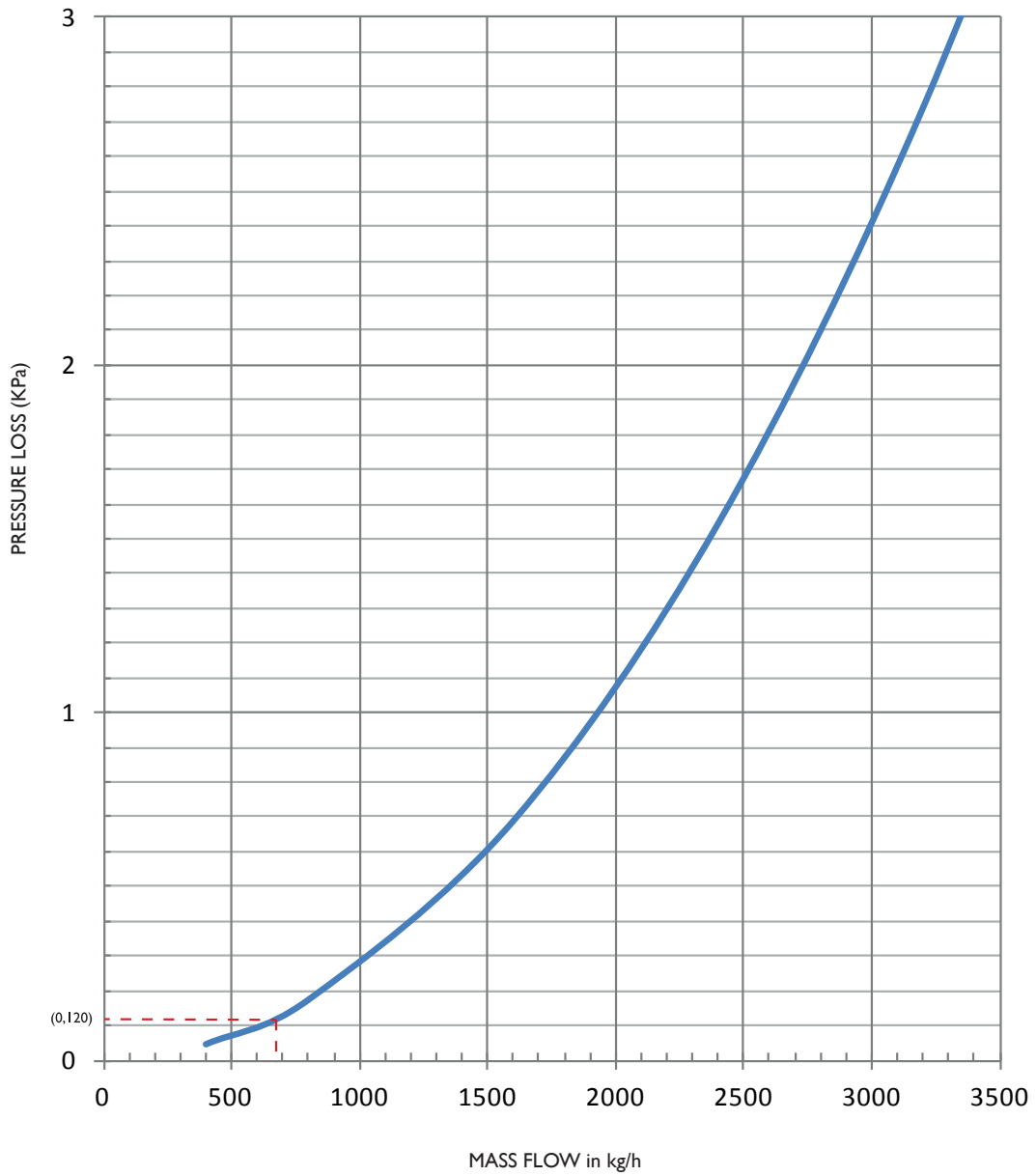
Total: $800 + 360 = 1160 \text{ Pa}$



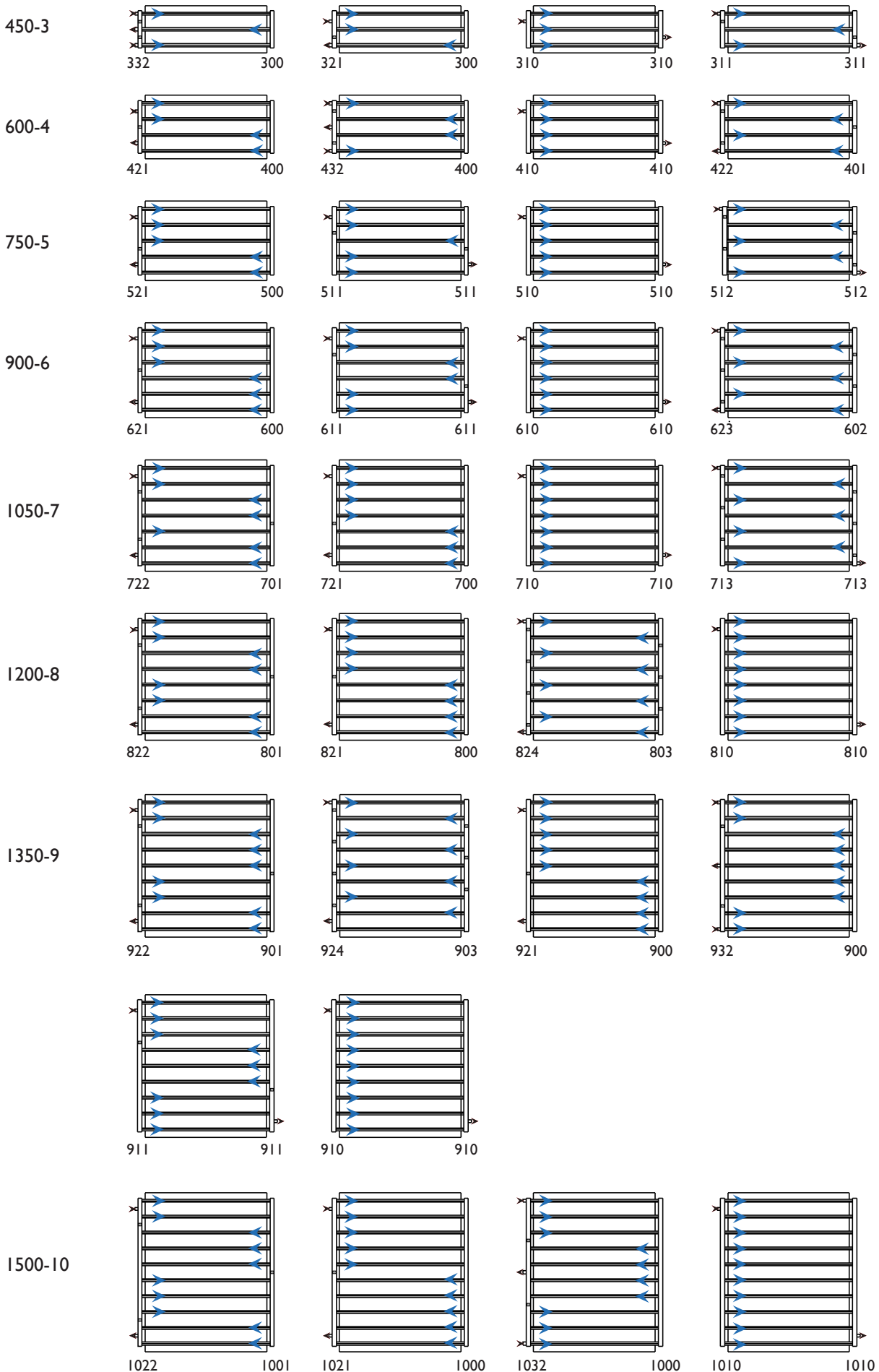
PRESSURE LOSS IN PIPE



PRESSURE LOSS IN COLLECTORS AND CONNECTIONS

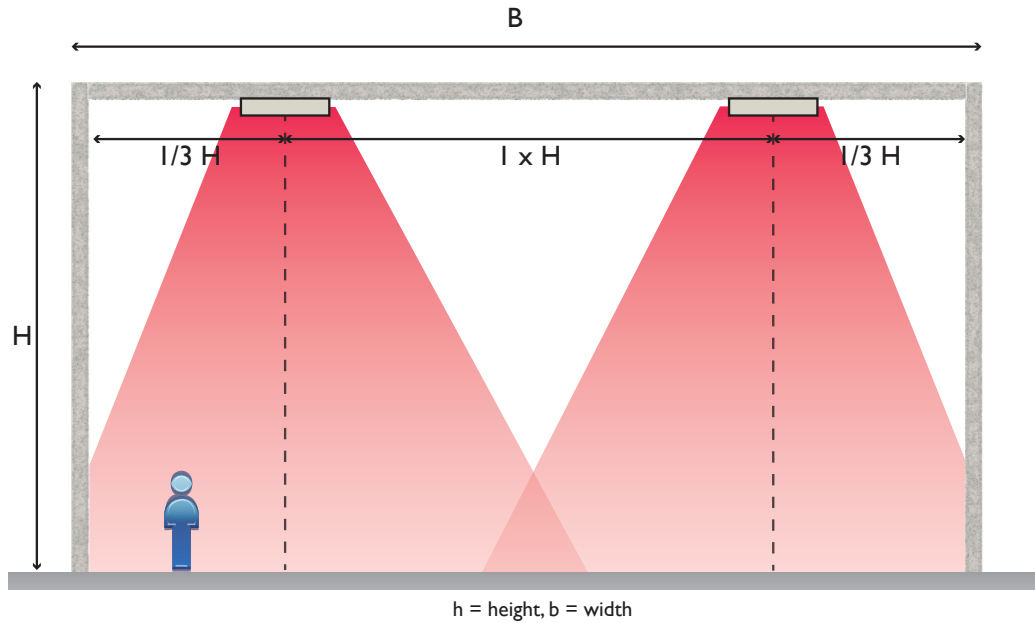


CONNECTION POSSIBILITIES (and flow direction of the fluid)



*The drawings above are provided with front connections. Top connections are also possible.

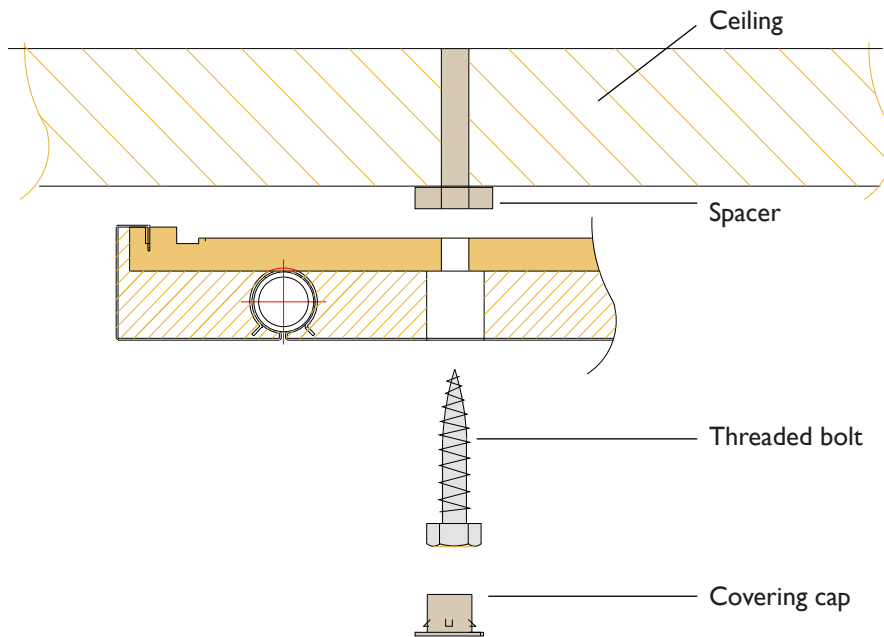
Project planning, assembly and suspension



ASSEMBLY TIGHTLY AGAINST THE CEILING

When the panel is mounted tightly against the ceiling, this gives an attractive effect and when used in a sports hall no ball removal plates will be needed.

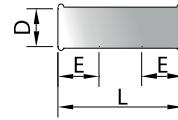
Mark B.V. can deliver panels with 18 mm holes in the aluminium profile of the panel at the location of the points of suspension which enables the mounting of the panel directly against the ceiling. The holes can be covered after installation with covering caps in the colours black or white. Because of the linear expansion of the panel is the maximum length with this suspension method is 24 m.



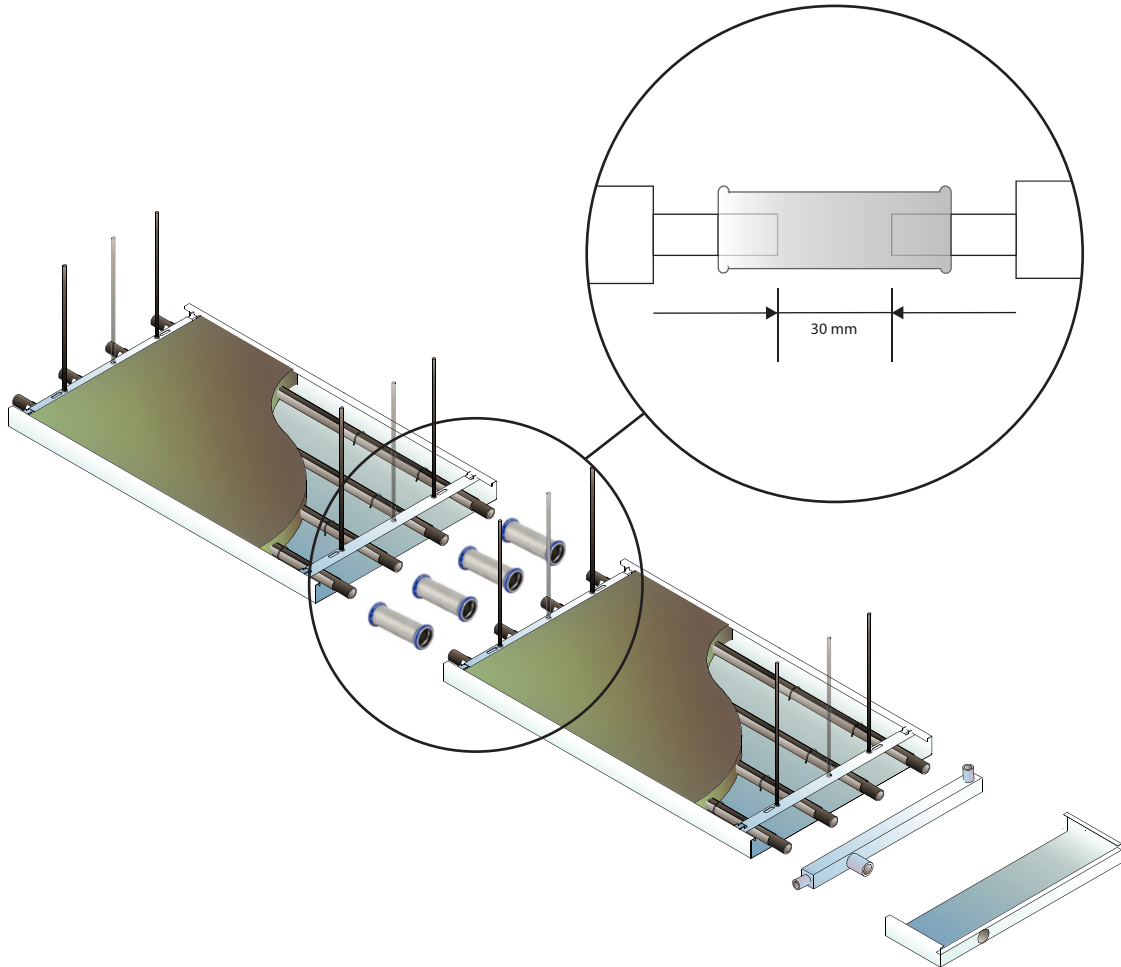
PRESS FITTINGS

Mark B.V. delivers approved press fittings as an option. Applying other fittings can lead to leaks for which Mark B.V. cannot be held liable.

When installing the press fittings, a gap of approximately 30 mm between the tubes of the radiant panels must be taken into account. Slide the press fittings one by one onto the tubes.

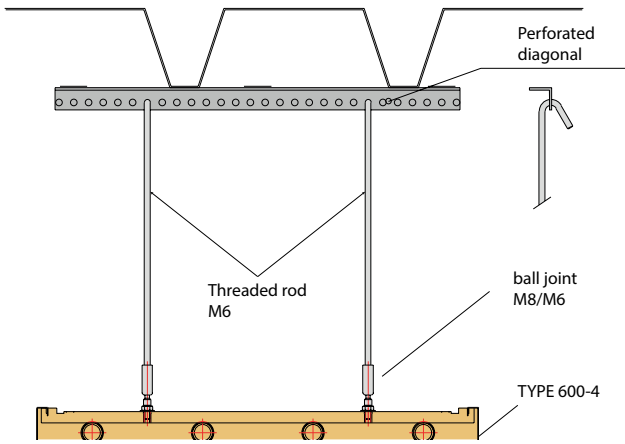


D	L	Z	E
28	91	-	30

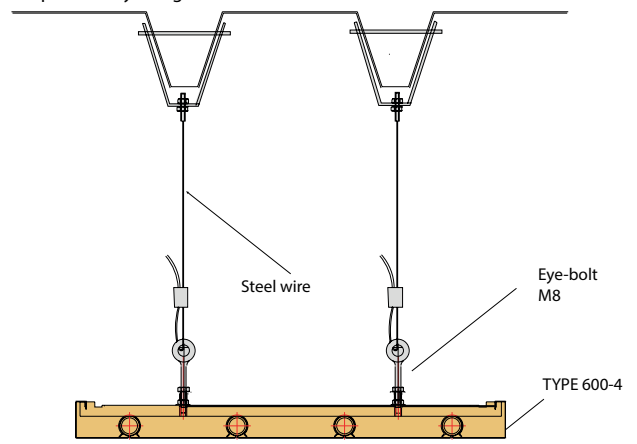


MOUNTING METHODS

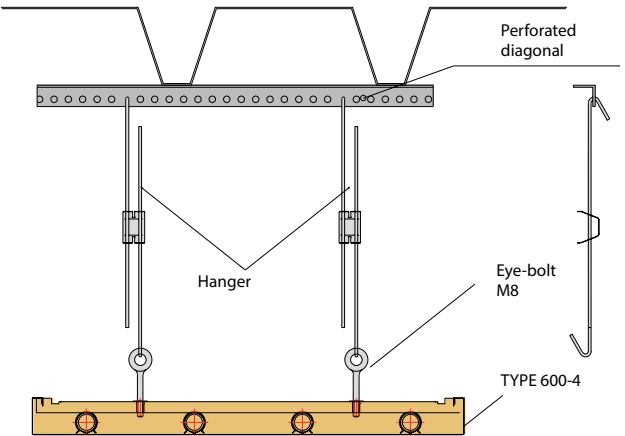
Method A: by using threaded rods.



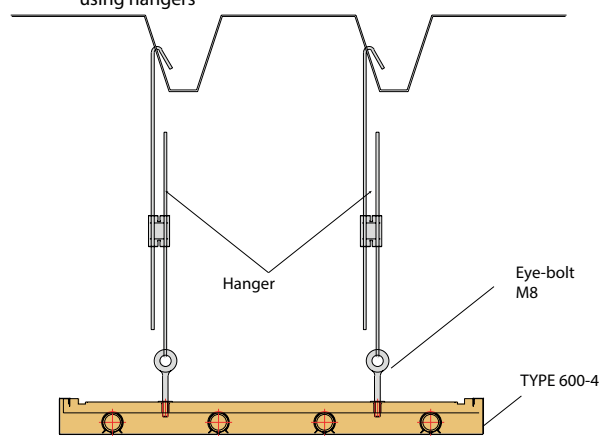
Method B suspension by using steel wire



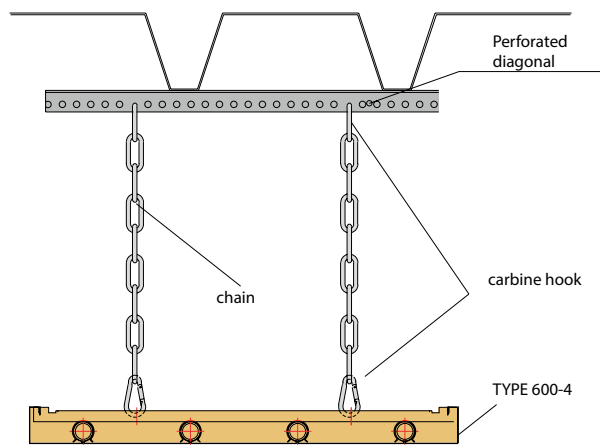
Method C: by using hangers.



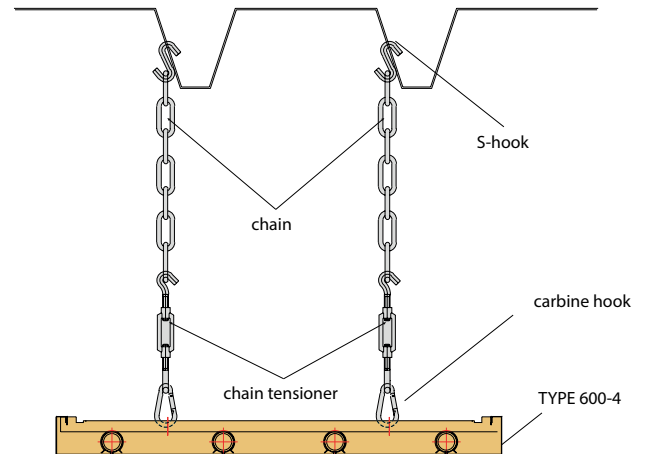
Method D: suspension by using hangers



Method E: by using chains.



Method F: suspension by using chains an chain tensioners



Control

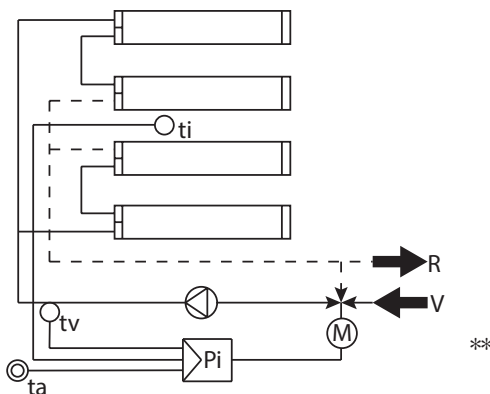
WATER-SIDED

A low water content of the system and a relatively high flow rate of the heating medium results in a very good controllability of the installation. To maintain a constant design temperature to maintain, the control should be through the flow temperature of the heating medium based on a mixing arrangement so that a turbulent flow in the tubes is maintained.

WEATHER DEPENDENT FLOW TEMPERATURE CONTROL

With room temperature compensation

The set value X_s of the outdoor controller is shifted until the desired temperature t_i is reached.



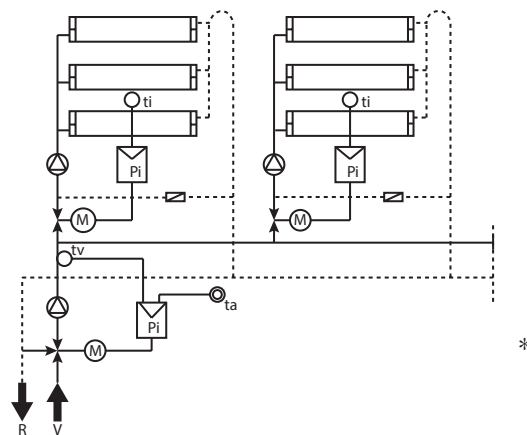
ROOM TEMPERATURE

The room temperature is preferably controlled by means of a black bulb sensor. (see accessories).

ZONE CONTROL

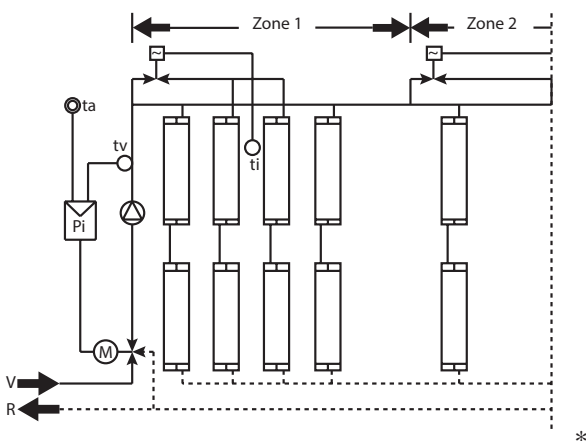
In order to obtain different indoor temperatures t_i

For example, a production area of 18°C and a warehouse of 16°C. The outdoor temperature control as pre-control enables to work with a higher supply temperature than is strictly necessary for the individual zones.



ZONE INDOOR TEMPERATURE CONTROL

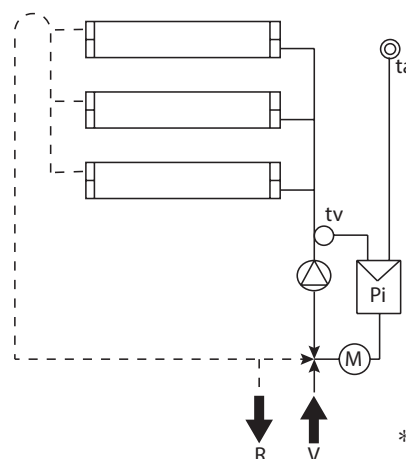
By switching off and the switching on/off of the radiant panels. Weather-dependant supply temperature control with PI controller, supplemented with a room thermostat controlled solenoid valve, which switches a portion of the water sided heated surface in case the set value X_s of the room thermostat is exceeded. With a pump, several areas can be fed water-sided. Each zone is divided in at least 2 groups water-sided. Very favourable control system for installations with extreme heat load and for time-controlled temperature reductions (e.g.: night and weekend reductions).



WEATHER DEPENDENT SUPPLY TEMPERATURE 2


Handling (no control) of the inside temperature T_i by the supply temperature t_v .

Simplest solution, without feedback from the indoor temperature t_i .



* Piping network according Tichelman.

** Piping network connected in series to provide the outer panels with a higher heat output.

ta = outside temperature | ti = inside temperature | tv = supply temperature | Pi = regulator | R = return line | V = supply line
M = motor-operated valve |  = cartridge

Logistics



Transport unit
(Maximum stack of 20 panels per pallet)

PACKAGING

Each Mark radiant panel is wrapped in protective foil and stacked up to a maximum of 20 panels. Panels are stacked alternately and at the part of the tubes, the panels are provided with filling timber. Pipe ends and collectors are provided with cable ties. The panels are transported on a pallet.

DELIVERY AND UNLOADING

The manufacturing of the Mark radiant panels is project-based. The pressure during the testing of the panels is 16 bar and after the final inspection (each panel is manually cleaned and checked), much attention is being paid to the packaging and transport.

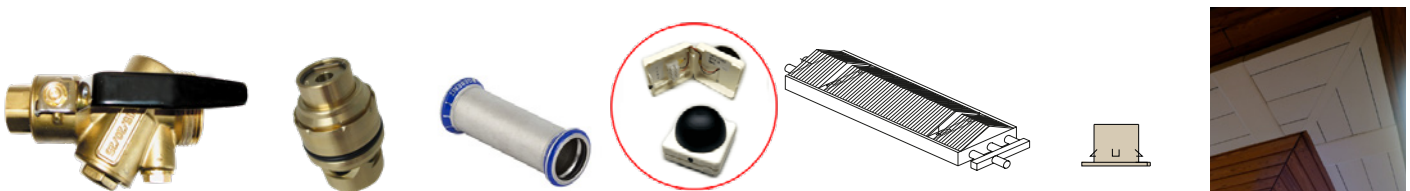
FINISHING

Mark delivers the panels in the colour RAL 9010 as standard. As an option, any RAL colour is available with an extra over price.

Accessories & parts

Possible accessories to be supplied are:

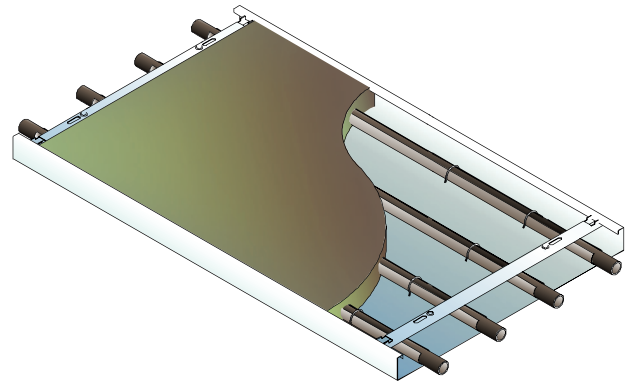
- Flow controllers
- High pressure cartridges
- Press fittings
- Corner panels
- Ball removal plates
- Plate covers
- Black bulb sensors



Specifications

INSULATED WITH PUR HARD FOAM

- Mark radiant panels, consisting of a water-fed register, composed of from a 28 mm steel pipe. The standard pipe distance is 150 mm.
- Standard black pipe. Galvanized pipe on request. Hanging tubular profile 15 x 15 x 1.5 mm. Provided with 2 pieces of M8 blind rivet nuts with the exception of type 1200-8 where 3 pieces M8 blind rivet nuts are used.
- Welded collectors, consisting of tubular profile 40 x 40 x 2.5 mm at the ends provided with welded end plates. Collectors are equipped with anti-rust paint in the colour grey. Collectors are provided with the necessary connector fittings: 1/2", 3/4" or 1".
- Aluminium profiled panels, viewed side foreseen with a polyester coating, RAL 9010 matt. Temperature up to 120°C. Aluminium plate thickness is 0.75 mm. Connecting pipe/plate by means of clamping springs.
- Mineral wool insulation thickness 40 mm. Thermal conductivity group 040. Provided with insulate holders.
- Fire Class A1/A2
- Covered with reinforced double layer aluminium
- Aluminium cover plates, width 150 mm, RAL 9010, with slots 3 x 9 mm for fixation. Self-drilling, galvanized tapping screws, 2.9 x 9.5 mm.
- Aluminium end cap, width 100 mm, colour RAL 9010. Mounting profile with mounting strip. Slots 3 x 9 mm for fixation. Self-drilling galvanized tapping screws, 2.9 x 9.5 mm. To be mounted after the installation of the panel for the finishing of the collector.
- Standard panel lengths of 3, 4, 5 and 6 meters. Any length up to 6 meter can be delivered.
- Packaging: panels are packed in foil.
- Because of the transportability the panels are packed with lengths of maximum 6 meters and assembled by the installer on site to obtain the desired length.
- Mounting brackets are supplied on request.
- Working pressure up to 16 Bar.





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