EnergoAqua Eco

Water Supplied Radiant Heating

Technical Information - EAE

ENERGOTECH

ENERGY EFFICIENT HEATING SYSTEMS

INDEX

1 PRODUCT DESCRIPTION

The technical, constructional and dimensional data are not binding and may be modified with no advance notice.

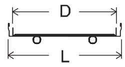
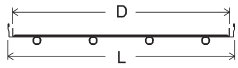
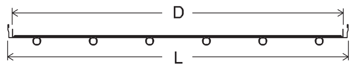
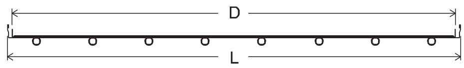
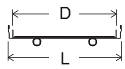
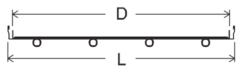
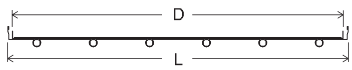
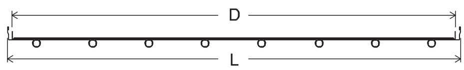
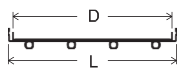
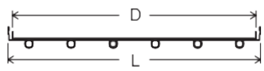
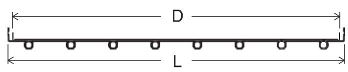
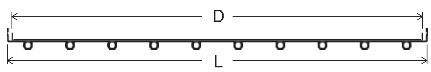
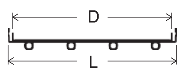
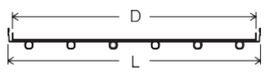
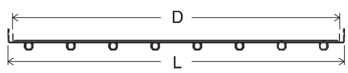
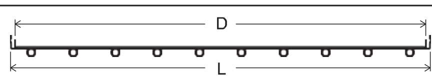
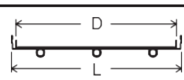
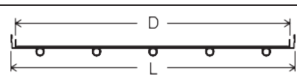
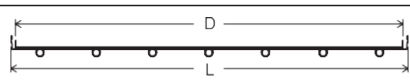
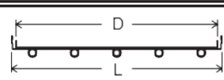
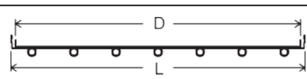
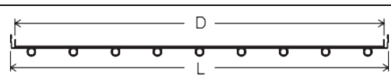
The European standard EN 14037 defines how to measure thermal emission, which can then be used to compare the various ceiling mounted radiant panels available on the market.

To make it easier to use this product, we feel it is helpful to provide a manual that contains all necessary technical data.

WATER SUPPLIED RADIANT PANELS

1 PRODUCT DESCRIPTION

1.1 Models, dimensions, weights, water contents - *Tab.1*

	Distance between tubes mm	Outside tube diameter mm	Cross section	Model	**Nominal thermal emission** (*) $\Delta = 55$ K **W/m**	Total width L mm	Distance of suspensions D mm
	150	21,3		**2/150 ½”**	**180**	300	270
	150	21,3		**4/150 ½”**	**309**	600	570
	150	21,3		**6/150 ½”**	**431**	900	870
	150	21,3		**8/150 ½”**	**554**	1200	1170
	150	26,9		**2/150 ¾”**	**190**	300	270
	150	26,9		**4/150 ¾”**	**318**	600	570
	150	26,9		**6/150 ¾”**	**449**	900	870
	150	26,9		**8/150 ¾”**	**581**	1200	1170
	111	21,3		**4/100 ½”**	**278**	450	420
	111	21,3		**6/100 ½”**	**413**	675	650
	111	21,3		**8/100 ½”**	**516**	900	870
	111	21,3		**10/100 ½”**	**616**	1120	1090
	111	26,9		**4/100 ¾”**	**279**	450	420
	111	26,9		**6/100 ¾”**	**415**	675	650
	111	26,9		**8/100 ¾”**	**534**	900	870
	111	26,9		**10/100 ¾”**	**650**	1120	1090
NON-STANDARD PANELS	150	21,3		**3/150 ½”**	**244**	450	420
	150	21,3		**5/150 ½”**	**370**	750	720
	150	21,3		**7/150 ½”**	**492**	1050	1020
	111	21,3		**5/100 ½”**	**347**	565	535
	111	21,3		**7/100 ½”**	**466**	790	760
	111	21,3		**9/100 ½”**	**566**	1010	980

Empty weight		Weight with water		Water contents (**) dm³/m
Panel (**) kg/m	Header kg	Panel (**) kg/m	Header kg	
4,7	1,1	5,23	1,8	0,53
5,4		5,84		0,44
8,7	2,0	9,75	3,3	1,05
10,1		10,98		0,88
12,7	2,9	14,28	4,8	1,58
14,9		16,21		1,31
16,8	3,8	18,90	6,3	2,10
19,7		21,45		1,75
5,1	1,1	6,00	1,8	0,90
6,1		6,88		0,78
9,7	2,0	11,50	3,3	1,80
11,6		13,16		1,56
14,3	2,9	16,99	4,8	2,69
17,1		19,45		2,35
18,9	3,8	22,49	6,3	3,59
22,6		25,73		3,13
7,6	1,5	8,65	2,5	1,05
9,1		9,98		0,88
11,0	2,1	12,58	3,6	1,58
13,1		14,41		1,31
14,5	2,8	16,60	4,7	2,10
17,4		19,15		1,75
18,0	3,5	20,63	5,8	2,63
21,8		23,99		2,19
8,7	1,5	10,50	2,5	1,80
10,5		12,06		1,56
12,6	2,1	15,29	3,6	2,69
15,3		17,65		2,35
16,7	2,8	20,29	4,7	3,59
20,4		23,53		3,13
20,9	3,5	25,39	5,8	4,49
25,5		29,41		3,91
6,7	1,5	7,49	2,5	0,79
7,8		8,46		0,66
10,8	2,4	12,11	4,1	1,31
12,6		13,69		1,09
14,9	3,4	16,74	5,7	1,84
17,4		18,93		1,53
9,3	1,8	10,61	3,1	1,31
11,1		12,19		1,09
12,8	2,5	14,64	4,2	1,84
15,3		16,83		1,53
16,3	3,2	18,67	5,3	2,37
19,6		21,57		1,97

(*) Nominal thermal output as per EN 14037, based on tests carried out at the HLK laboratory at the University of Stuttgart.
This emission is relative to $\Delta T = 55$ K, where ΔT is the difference between the average temperature of the fluid and the ambient temperature

(**) Top line: with electro-welded tube
Lower line: tube with no welding

Maximum operating pressure: 6 bar.

The suspension brackets for the radiant panel are designed withstand a load that is five times greater than the weight of the panel including water without failure. The panel is able to support a load which is three times its own weight, including water, with no permanent deformation.

04

EN 14037-1 Ceiling mounted radiant panels
Maximum operating pressure: 6 bar

1.2 Construction

EnergoAqua, EAE, radiant panels are produced by permanently inserting tubes in a suitably shaped plate of steel sheet metal, including the side edges.
The latest technologies are used to make circular grooves in the plate at regular distances.
The tubes are inserted into these grooves. The profile of the plate is wrapped around two thirds of the circumference of each single tube holding it in place.
At the top, at intervals of about one meter, transversal brackets are placed. They make the entire system rigid and allow the support ties to be attached. At the worksite, the insulating mat provided is inserted between the side edges.

EAE panels use tested electro-welded steel tubes (measuring either ½” or ¾”). They are used in system supplied with water at up to 120 °C.
For superheated water, steam, diathermic oil, etc., steel tubes are used which are not welded UNI 8863, made of steel, and measuring ½” or ¾”.

1.3 Production, modularity

The EAE radiant panels are produced in a variety of models:

- with tubes spaced at 150 mm, there are seven models with tubes of ½” and four with tubes of ¾”.
- with tubes spaced at 111 mm, there are seven models with tubes of ½” and four with tubes of ¾”.

Table 1 provides a summary of the range of products.

The sheet metal used to make plates is 0,6 mm thick and about 2 meters long. They are assembled to provide modules with lengths of either 4 or 6 meters.
Fig. 1 shows the dimensions of the modules of 4 or 6 meters that make up the radiant panels.
By combining these modules, it is possible to obtain radiant panels of any length in multiples of two, starting from a minimum length of 4 meters.
To ensure continuity of the panels at the points of welding of the various modules, joint covers are provided that have the same cross section as the panel. They are installed using steel clips.

1.4 Suspension brackets

Suspension brackets are positioned on the panels about one every meter.
Fig. 2 shows the exact distance between the brackets.
When positioning the tubes in service, there should normally be one suspension every two meters.
The panels with pipes of ¾” may have spacing increased by up to 30%.
Panels with a width of 60 cm or less may have suspension points with a distance of over 3 meters between them.
Distances between suspensions which are greater than those indicated above may lead to permanent deformation.

1.5 Headers / Collectors

The headers have a square cross section (50x50 mm) for panels with electro-welded tubes and a round cross-section (Ø 60 mm) for panels with pipes without welding.
Different types are provided (*fig. 3*) depending on the fluid used and the supply mode.
They are normally provided welded to the panels.

1.6 Paint

After undergoing a phosphate treatment, the panels are painted by immersion using water-soluble paints with non-toxic epoxy resin base. They are then sent to a kiln.
The standard colour is RAL 9016, white.
This paint is resistant up to 170°C with water systems and up to 140°C for steam systems.
On request, and for higher temperatures, the panels can be treated with special paints.
For colours other than the standard colour, after washing, de-greasing and phosphating, the panels are painted with powder treatment that is free of harmful substances.

1.7 Insulation

Standard EN 14037 requires the laboratory which tests the output of the panels to provide them with a layer of rock wool with a thickness of 40 mm, minimum density 25 kg/m^3, thermal conductivity 0.04 W/mK at 40 °C, covered on the upper side by aluminum foil.

The provided insulating material for the panels is non-carcinogenic fiberglass wool and has a thickness of 40 mm and covered on the upper side with aluminum foil.
For the insulation technical data, see *paragraph 4.2*.

The insulating mat is delivered in rolls. It is to be inserted between the edges of the upper side of the panel. It is easy to lay because there are no obstacles. This ensures perfect adherence to the radiant panel.

The mat is positioned using fixture points which are then placed in holes in the suspension bracket.

1.8 Operating temperature

EAE radiant panels with electro-welded tubes are suitable for carrying fluids at temperatures of up to 120 °C.
The version with pipes without welding can be used for fluids up to 180 °C.

1.9 Operating pressure

The factory pressure test, which is carried out on each welding, is 8 bar. The initial type testing for each model is 10,2 bar.
For panels with tubes without welding, the maximum operating pressure is 16 bar.

1.10 Special versions, accessories

- Panels with tubes of 1” without welding
- panels with tubes at a distance of 111 mm measuring ½” with 4 pipes - 6 pipes - 8 pipes with spaces for lamps
- anti-convection lateral skirts
- concealed side profiles for suspensions at variable intervals
- joint covers for pipe joints with sleeves for *press fitting*
- headers for assembly with *press fitting*
- insulation covers for heads of panels
- upper metal sheet protections for gymnasiums.

For a more detailed description, see *chapter 3* on accessories.

*Fig.1 **Longitudinal dimensions of the modules that make up the panels** (mm)*

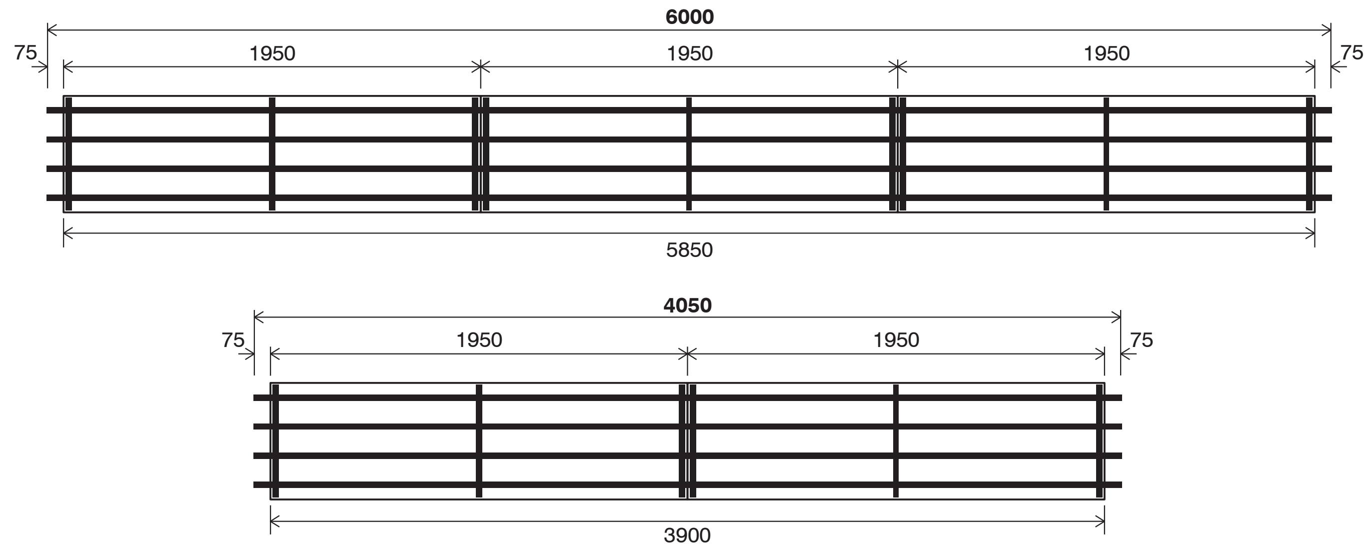


*Fig.2 **Suspension brackets** (mm)*

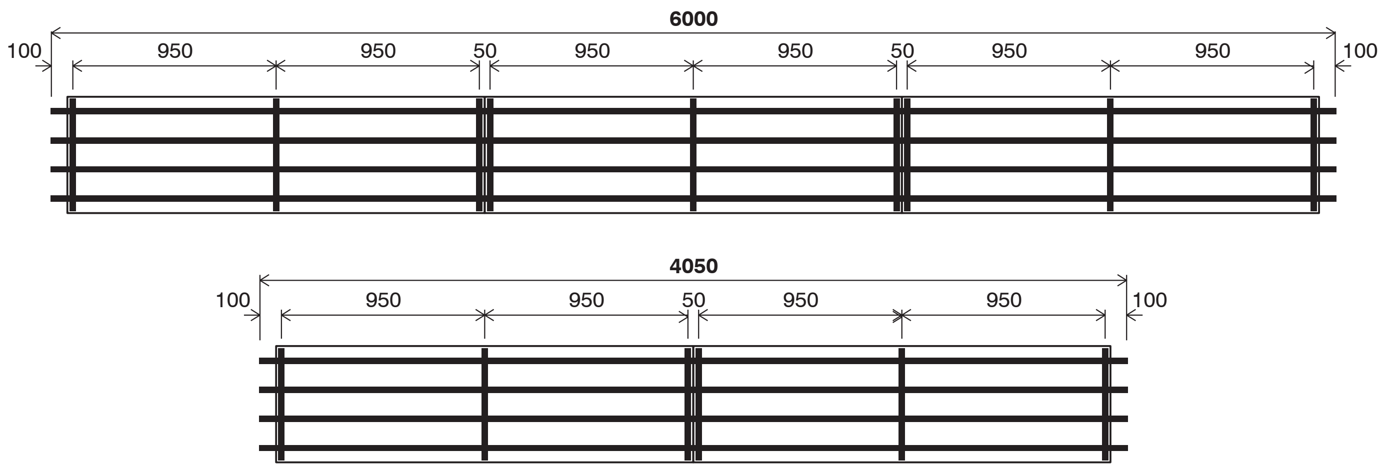
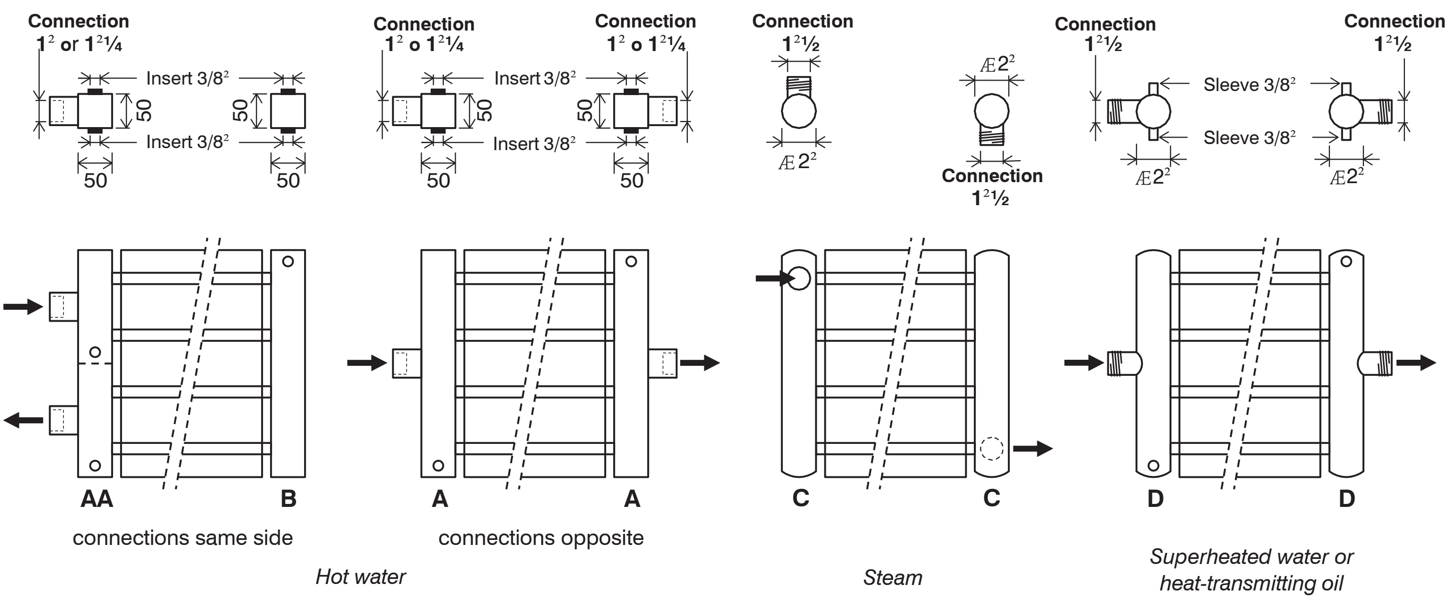


*Fig.3 **Headers - Execution AA, B, A, C, D** (mm)*



1.11 Components of the EnergoAqua Eco radiant panel

① Steel pipe, ½" or ¾”

② Steel plates in single piece, including side edges

③ Reinforcing and suspension bracket

④ Insulating mat

⑤ Fixture point / Plug for fastening insulating mat

⑥ Header

⑦ Female threaded connection, 1”¼ or 1”

⑧ Insert of 3/8” for vent or drain

⑨ Suspension ties (chain, steel cables, etc.) not included in supply

⑩ Joint covers with fastening clips

⑪ Anti-convective side skirts (on request)

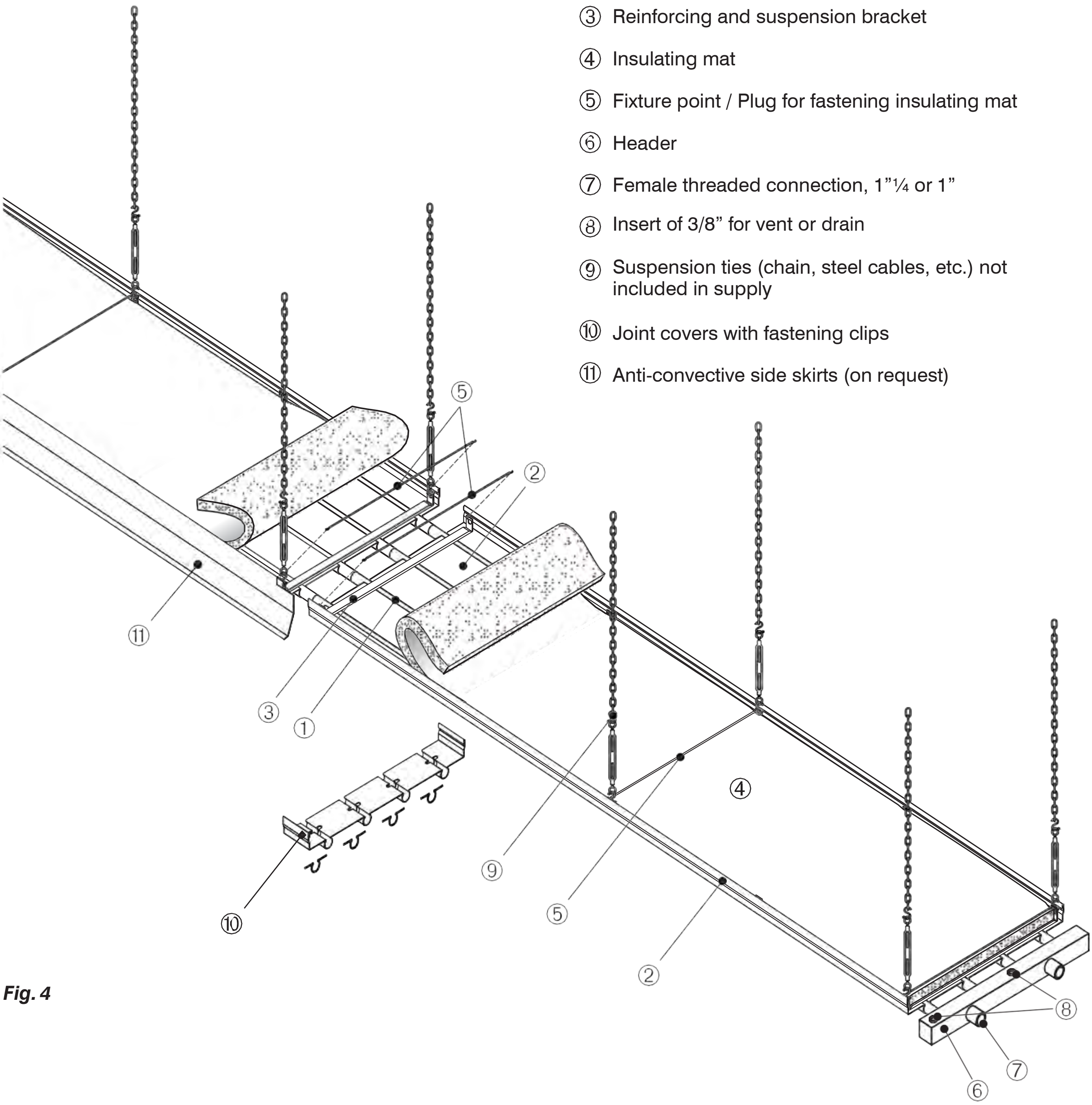
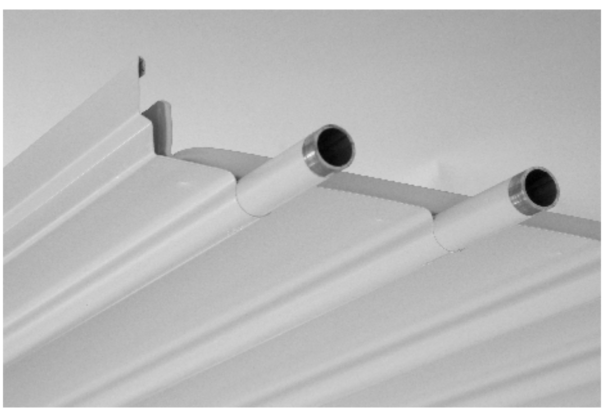
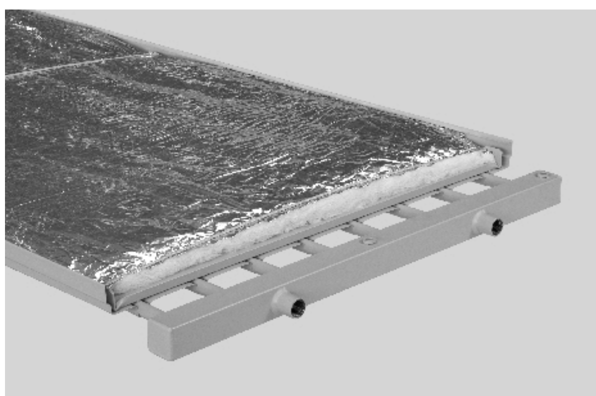


Fig. 4





2 DESIGN DATA

2.1 Guidelines for a correct choice

The EAE range of radiant panels includes
22 different models:

- **with distances between tubes of 111 mm,** seven with tubes of ½" and four with tubes of ¾"
- **with distances between tubes of 150 mm,** seven with tubes of ½" and four with tubes of ¾".

Each model can be provided with electro-welded tubes or tubes without welding.

All of these models provide the designer with a wide choice.
Tab. 2 shows the guidelines for choosing the type, diameter and distance between the panel

Tab.2 Selection criteria

SELECTION CRITERIA	tubes ½" *distance:*		tubes ¾" *distance:*	
	111 mm	*150 mm*	*111 mm*	*150 mm*
Short radiant panels: *up to 40 m with same-side connections, 80 m with opposite connections*	×	×		
Long radiant panels: *over 40 m with same side connections or 80 m with opposite connections*			×	×
High-ceiling rooms	×		×	
Low-ceiling rooms *(h <3.5 meters)*		×		×
Water flow rate per pipe *from 250 to 500 l/h*	×	×		
Water flow rate per pipe *from 500 to 1000 l/h*			×	×
Water heating fluid *up to 120 °C*	Electro-welded pipes			
Steam	Tubes without welding (UNI 8863)			
Superheated water				
Heat-transmitting oil				

2.2 Active length

Standard EN 14037 defines active length as the part of the panel with the same transversal cross-section, excluding headers and joint covers.

An EAE panel of 6 meters has an active length (L_{act}) of 5,85 meters.

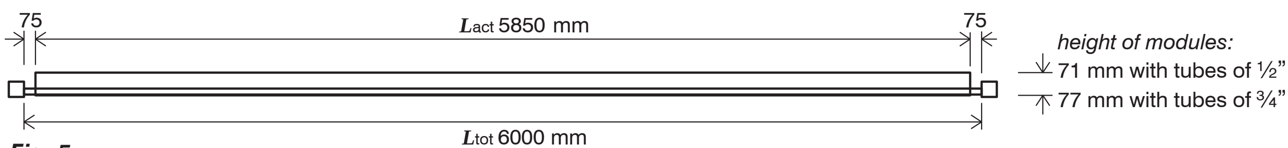


Fig. 5

An EAE panel of 8 meters, made up of two modules each with a length of 4,05 meters, has an active length (L_{act}) of 7,8 meters.

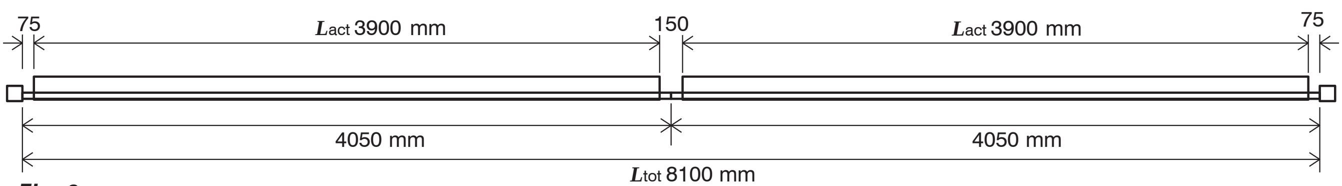
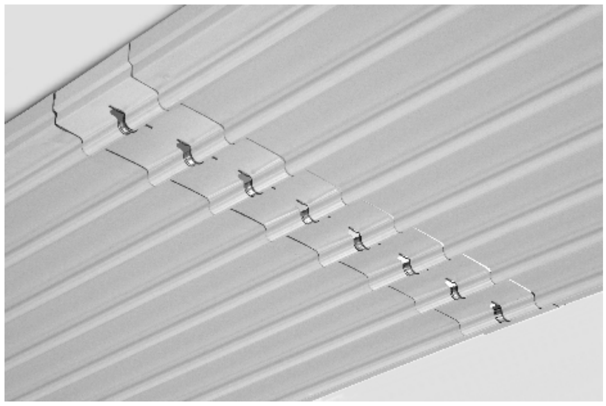


Fig. 6

An EAE panel of 12 meters, made up of two modules of 6 meters, has an active length (L_{act}) of 11,70 meters.

An EAE panel of 14 meters, made up of two modules of 4,05 meters and one module of 6 meters, has an active length (L_{act}) of 13,65 meters.

The examples above show that between the total length of the panels and their active length, there is a difference of about 3%. This is as opposed to an average difference of 5% in other panels available on the market.
In designing EAE panels, an attempt has been made to reduce this difference to a minimum.
For this reason, a joint cover of 15 cm that is inserted to cover the joint between two modules has the same profile as the main sheet metal. Therefore it is also radiant.
Laboratory tests show that it performs exactly like the active part of the panel.



2.3 Thermal output

Tests based on European standard EN 14037 were carried out and certified by the HLK laboratory of the University of Stuttgart.
The thermal output of the EAE radiant panels are shown in *Tables 3* and *4*.
Tables 5 and *6* provide the output of a pair of headers for the various models of panels.
The tables show the values of thermal power based on the difference (ΔT) between the average temperature of the fluid (t_m) and the ambient temperature (t_a).
The certified output is for the active length of a radiant panel.

Tab.3 Table of thermal emissions per linear meter as per standard EN 14037

EnergoAqua Eco radiant panels - tubes of ½”

MODEL	4/100	5/100 (**)	6/100	7/100 (**)	8/100	9/100 (**)	10/100	2/150	3/150 (**)	4/150	5/150 (**)	6/150	7/150 (**)	8/150
Distance between tubes mm	111	111	111	111	111	111	111	150	150	150	150	150	150	150
Width mm	450	565	675	790	900	1010	1120	300	450	600	750	900	1050	1200
No. of tubes n°-Ø	4 - ½”	5 - ½”	6 - ½”	7 - ½”	8 -½”	9 - ½”	10 - ½”	2 - ½”	3 - ½”	4 - ½”	5 - ½”	6 - ½”	7 - ½”	8 - ½”
$\Delta T = t_m - t_a$ (*) K	**W/m**	**W/m**	**W/m**	**W/m**	**W/m**	**W/m**	**W/m**	**W/m**	**W/m**	**W/m**	**W/m**	**W/m**	**W/m**	**W/m**
20	84	105	125	141	156	171	186	55	75	95	114	132	151	170
22	94	118	140	158	175	191	208	61	84	106	127	148	169	190
24	104	130	156	175	194	212	231	68	93	117	141	164	187	210
26	115	143	171	192	213	233	254	75	102	129	154	180	205	231
28	125	156	186	210	232	255	277	81	111	140	168	196	224	251
30	136	170	202	228	252	276	300	88	120	152	182	212	243	273
32	146	183	218	246	272	298	324	95	130	164	197	229	262	294
34	157	197	234	264	292	320	348	102	139	176	211	246	281	316
36	168	210	251	282	313	343	373	109	149	188	226	263	300	337
38	179	224	267	301	333	365	398	117	159	201	240	280	320	359
40	191	238	284	320	354	388	423	124	168	213	255	297	339	382
42	202	252	301	339	375	411	448	131	178	225	270	315	359	404
44	213	267	318	358	396	435	473	138	188	238	285	332	379	427
46	225	281	335	377	418	458	499	146	198	251	300	350	400	449
48	236	295	352	397	439	482	524	153	208	263	316	368	420	472
50	248	310	369	416	461	506	551	161	219	276	331	386	441	495
52	260	325	387	436	483	530	577	169	229	289	347	404	461	519
54	272	340	404	456	505	554	603	176	239	302	362	422	482	542
ΔT_s 55	**278**	**347**	**413**	**466**	**516**	**566**	**616**	**180**	**244**	**309**	**370**	**431**	**492**	**554**
56	284	354	422	476	527	578	630	184	250	315	378	440	503	566
58	296	369	440	496	549	603	656	192	260	328	394	459	524	589
60	308	385	458	516	572	628	683	199	271	342	410	477	545	613
62	320	400	476	536	594	652	710	207	281	355	426	496	566	637
64	332	415	494	557	617	677	738	215	292	368	442	515	588	661
66	345	430	512	577	640	702	765	223	303	382	458	534	609	685
68	357	446	531	598	663	728	793	231	313	395	474	552	631	710
70	369	461	549	619	686	753	820	239	324	409	490	572	653	734
72	382	477	568	640	709	779	848	247	335	423	507	591	675	759
74	395	493	586	661	733	804	876	255	346	436	523	610	697	783
76	407	508	605	682	756	830	904	263	357	450	540	629	719	808
78	420	524	624	703	780	856	933	271	368	464	556	648	741	833
80	433	540	643	725	803	882	961	280	379	478	573	668	763	858
82	446	556	662	746	827	908	990	288	390	492	590	687	785	883
84	458	572	681	768	851	935	1018	296	401	506	606	707	808	908
86	471	588	700	789	875	961	1047	304	412	520	623	727	830	934
88	484	604	719	811	899	987	1076	313	424	534	640	747	853	959
90	497	621	738	833	923	1014	1105	321	435	548	657	766	876	985
92	510	637	758	855	948	1041	1134	330	446	563	674	786	898	1010
94	524	653	777	877	972	1068	1164	338	458	577	692	806	921	1036
96	537	670	797	899	997	1095	1193	346	469	591	709	826	944	1062
98	550	686	816	921	1021	1122	1222	355	481	606	726	847	967	1088
100	563	703	836	943	1046	1149	1252	363	492	620	743	867	990	1114
102	577	719	856	965	1071	1176	1282	372	504	635	761	887	1013	1140
104	590	736	875	988	1095	1203	1312	381	515	649	778	907	1037	1166
106	604	753	895	1010	1120	1231	1342	389	527	664	796	928	1060	1192
108	617	770	915	1033	1145	1258	1372	398	538	678	813	948	1083	1219
110	631	786	935	1055	1171	1286	1402	407	550	693	831	969	1107	1245
112	644	803	955	1078	1196	1314	1432	415	562	708	848	989	1130	1272
114	658	820	975	1101	1221	1342	1462	424	574	722	866	1010	1154	1298
116	672	837	996	1124	1246	1369	1493	433	585	737	884	1031	1178	1325
118	685	854	1016	1146	1272	1397	1524	441	597	752	902	1052	1202	1352
120	699	872	1036	1169	1297	1426	1554	450	609	767	920	1072	1225	1379

ΔT_s = standard temperature difference, gray area of the table

(*) ΔT = *difference between the average temperature of the fluid and the ambient temperature* (**) = *non-standard panels*

Tab.4 Table of thermal emissions per linear meter as per standard EN 14037

EnergoAqua Eco radiant panels - tubes of ¾"

MODEL		4/100	6/100	8/100	10/100	2/150	4/150	6/150	8/150
Distance between tubes mm	111	111	111	111	150	150	150	150	150
Width	mm	450	675	900	1120	300	600	900	1200
No. of tubes	n°- Ø	4 - ¾"	6 - ¾"	8 - ¾"	10 - ¾"	2 - ¾"	4 - ¾"	6 - ¾"	8 - ¾"
$\Delta T = t_m - t_a$ (*)	K	W/m	W/m	W/m	W/m	W/m	W/m	W/m	W/m
	20	84	126	161	196	58	97	137	176
	22	94	141	181	219	65	108	153	197
	24	105	156	200	243	72	120	169	219
	26	115	171	220	267	79	132	186	240
	28	126	187	240	292	86	144	203	262
	30	136	203	261	317	93	156	220	284
	32	147	219	281	342	100	168	237	307
	34	158	235	302	367	108	181	255	330
	36	169	252	323	393	115	193	273	353
	38	180	268	345	419	123	206	291	376
	40	192	285	366	446	131	219	309	399
	42	203	302	388	472	138	231	327	423
	44	215	319	410	499	146	245	346	447
	46	226	336	432	526	154	258	364	471
	48	238	353	454	553	162	271	383	495
	50	250	370	477	581	170	284	402	519
	52	261	388	499	608	178	298	421	544
	54	273	406	522	636	186	311	440	568
	55	**279**	**415**	**534**	**650**	**190**	**318**	**449**	**581**
	56	285	423	545	664	194	325	459	593
	58	298	441	568	692	202	338	478	618
	60	310	459	592	721	210	352	498	644
	62	322	477	615	749	219	366	517	669
	64	334	496	638	778	227	380	537	694
	66	347	514	662	807	235	394	557	720
	68	359	532	686	836	244	408	577	746
	70	372	551	710	865	252	422	597	772
	72	384	570	734	895	261	436	617	798
	74	397	588	758	924	269	451	637	824
	76	410	607	782	954	278	465	658	850
	78	423	626	807	984	286	479	678	877
	80	435	645	831	1014	295	494	698	903
	82	448	664	856	1044	304	509	719	930
	84	461	683	881	1074	312	523	740	957
	86	474	702	905	1104	321	538	761	984
	88	488	722	930	1135	330	553	781	1011
	90	501	741	955	1166	339	567	802	1038
	92	514	760	981	1196	348	582	823	1065
	94	527	780	1006	1227	357	597	844	1092
	96	540	800	1031	1258	366	612	866	1120
	98	554	819	1057	1289	375	627	887	1147
	100	567	839	1082	1321	384	642	908	1175
	102	581	859	1108	1352	393	657	930	1203
	104	594	879	1134	1383	402	673	951	1230
	106	608	899	1159	1415	411	688	973	1258
	108	621	919	1185	1447	420	703	994	1286
	110	635	939	1211	1479	429	718	1016	1314
	112	649	959	1237	1511	438	734	1038	1343
	114	662	979	1264	1543	447	749	1060	1371
	116	676	1000	1290	1575	457	765	1082	1399
	118	690	1020	1316	1607	466	780	1104	1428
	120	704	1040	1343	1639	475	796	1126	1456

ΔT_s = standard temperature difference, gray area of the table

(*) ΔT = *difference between the average temperature of the fluid and the ambient temperature*

Tab.5   Table of thermal emissions of headers as per standard EN 14037

Pair of headers for the EAE - tubes of ½”

MODEL	4/100	5/100 (**)	6/100	7/100 (**)	8/100	9/100 (**)	10/100	2/150	3/150 (**)	4/150	5/150 (**)	6/150	7/150 (**)	8/150
Distance between tubes mm	111	111	111	111	111	111	111	150	150	150	150	150	150	150
Width mm	450	565	675	790	900	1010	1120	300	450	600	750	900	1050	1200
No. of tubes n°-Ø	4 - ½”	5 - ½”	6 - ½”	7 - ½”	8 - ½”	9 - ½”	10 - ½”	2 - ½”	3 - ½”	4 - ½”	5 - ½”	6 - ½”	7 - ½”	8 - ½”
$\Delta T = t_m - t_a$ (*) K	W	W	W	W	W	W	W	W	W	W	W	W	W	W
20	36	44	52	58	64	71	77	22	34	46	58	71	83	96
22	40	50	59	66	73	80	87	25	38	52	66	80	94	108
24	45	55	66	73	81	89	96	27	43	58	73	89	104	120
26	49	61	73	81	90	98	107	30	47	64	81	98	115	133
28	54	67	80	89	98	108	117	33	52	70	89	107	126	145
30	59	74	87	97	107	117	128	36	57	77	97	117	137	158
32	64	80	95	106	117	127	138	39	61	83	105	127	149	171
34	69	86	102	114	126	137	149	42	66	90	113	137	160	184
36	74	93	110	123	135	148	160	45	71	97	122	147	172	197
38	80	99	118	132	145	158	171	48	76	103	130	157	184	211
40	85	106	126	140	154	169	183	51	81	110	139	167	196	224
42	90	113	134	149	164	179	194	55	86	117	147	177	208	238
44	96	119	142	158	174	190	206	58	91	124	156	188	220	252
46	101	126	150	168	184	201	218	61	96	131	165	199	232	266
48	107	133	159	177	194	212	230	64	102	139	174	209	245	280
50	113	140	167	186	205	223	242	68	107	146	183	220	257	294
52	118	148	176	196	215	234	254	71	112	153	192	231	270	309
54	124	155	184	205	226	246	266	74	118	161	201	242	283	323
ΔT_s 55	**127**	**158**	**189**	**210**	**231**	**251**	**272**	**76**	**120**	**165**	**206**	**248**	**289**	**331**
56	130	162	193	215	236	257	278	78	123	168	211	253	296	338
58	136	169	202	225	247	269	291	81	129	176	220	265	309	353
60	141	177	211	235	258	281	303	85	134	184	230	276	322	368
62	147	184	220	245	269	292	316	88	140	191	239	287	335	383
64	153	192	229	255	280	304	329	92	145	199	249	299	348	398
66	159	200	238	265	291	316	342	95	151	207	259	310	362	413
68	166	207	247	275	302	328	355	99	157	215	269	322	375	428
70	172	215	257	286	313	341	368	102	162	223	278	334	389	444
72	178	223	266	296	324	353	381	106	168	231	288	346	403	459
74	184	231	276	306	336	365	394	110	174	239	298	358	416	475
76	190	239	285	317	347	378	408	113	180	247	308	370	430	491
78	197	247	295	328	359	390	421	117	186	255	319	382	444	506
80	203	255	304	338	371	403	435	121	192	263	329	394	458	522
82	209	263	314	349	382	415	448	124	198	272	339	406	472	538
84	216	271	324	360	394	428	462	128	204	280	349	418	487	554
86	222	279	334	371	406	441	476	132	210	288	360	431	501	570
88	229	287	344	382	418	454	490	136	216	297	370	443	515	587
90	235	296	354	393	430	467	504	140	222	305	381	456	530	603
92	242	304	364	404	442	480	518	143	228	314	391	468	544	619
94	249	312	374	415	454	493	532	147	234	323	402	481	559	636
96	255	321	384	426	467	506	546	151	241	331	413	493	573	652
98	262	329	394	438	479	520	560	155	247	340	424	506	588	669
100	269	338	405	449	491	533	575	159	253	349	434	519	603	686
102	276	346	415	460	504	547	589	163	260	357	445	532	618	702
104	282	355	425	472	516	560	604	167	266	366	456	545	633	719
106	289	364	436	483	529	574	618	171	272	375	467	558	648	736
108	296	372	446	495	541	587	633	175	279	384	478	571	663	753
110	303	381	457	507	554	601	647	179	285	393	489	584	678	770
112	310	390	467	518	567	615	662	183	292	402	500	597	693	787
114	317	399	478	530	580	628	677	187	298	411	511	610	708	804
116	324	408	489	542	592	642	692	191	305	420	523	624	723	822
118	331	417	500	554	605	656	707	195	311	429	534	637	739	839
120	338	426	510	566	618	670	722	199	318	438	545	650	754	856

ΔT_s = standard temperature difference, gray area of the table

(*) ΔT = *difference between the average temperature of the fluid and the ambient temperature* (**) = *non-standard panels*

Tab.6 Table of thermal emissions of headers as per standard EN 14037

Pair of headers for the EAE - tubes of ¾”

MODEL		4/100	6/100	8/100	10/100	2/150	4/150	6/150	8/150
Distance between tubes	mm	111	111	111	111	150	150	150	150
Width	mm	450	675	900	1120	300	600	900	1200
No. of tubes	n°- Ø	4 - ¾”	6 - ¾”	8 - ¾”	10 - ¾”	2 - ¾”	4 - ¾”	6 - ¾”	8 - ¾”
$\Delta T = t_m - t_a$ (*)	**K**	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**
	20	43	57	67	77	20	49	79	110
	22	49	65	76	87	23	55	89	124
	24	55	72	84	97	25	62	99	138
	26	60	80	94	107	28	68	110	152
	28	66	89	103	117	31	75	120	167
	30	72	97	112	128	34	82	131	181
	32	78	105	122	138	36	89	142	197
	34	84	114	132	149	39	96	153	212
	36	90	123	142	160	42	103	165	227
	38	97	132	152	171	45	111	176	243
	40	103	141	162	183	48	118	188	259
	42	109	150	172	194	51	126	200	275
	44	116	160	183	206	54	133	212	291
	46	122	169	193	217	57	141	224	308
	48	129	179	204	229	60	149	236	324
	50	136	189	215	241	63	157	249	341
	52	143	199	226	253	66	165	261	358
	54	149	209	237	265	69	173	274	375
	55	**153**	**214**	**243**	**271**	**71**	**177**	**280**	**384**
	56	156	219	248	277	73	181	287	393
	58	163	229	260	290	76	189	300	410
	60	170	240	271	302	79	198	313	428
	62	178	250	283	315	82	206	326	445
	64	185	261	294	327	86	214	339	463
	66	192	271	306	340	89	223	352	481
	68	199	282	318	353	92	232	366	499
	70	206	293	330	366	96	240	379	517
	72	214	304	342	379	99	249	393	536
	74	221	315	354	392	102	258	407	554
	76	229	326	367	405	106	267	421	573
	78	236	337	379	418	109	276	435	592
	80	244	349	391	432	113	285	449	610
	82	251	360	404	445	116	294	463	629
	84	259	372	416	459	120	303	477	648
	86	267	383	429	472	123	312	491	668
	88	274	395	442	486	127	321	505	687
	90	282	407	455	500	130	330	520	706
	92	290	419	467	514	134	340	534	726
	94	298	431	480	528	138	349	549	745
	96	306	443	494	542	141	359	564	765
	98	314	455	507	556	145	368	578	785
	100	322	467	520	570	149	378	593	804
	102	330	479	533	584	152	387	608	824
	104	338	491	546	598	156	397	623	844
	106	346	504	560	612	160	407	638	865
	108	354	516	573	627	163	417	653	885
	110	362	529	587	641	167	426	668	905
	112	370	541	601	656	171	436	684	925
	114	379	554	614	670	175	446	699	946
	116	387	567	628	685	179	456	714	967
	118	395	579	642	700	182	466	730	987
	120	404	592	656	714	186	476	745	1008

ΔT_s = standard temperature difference

(*) ΔT = *difference between the average temperature of the fluid and the ambient temperature*

2.4 Corrective coefficients for high installation heights

When the radiant panels installation height is over 6 meters, consideration must be made of the reduced radiant effects at the level of the room of the occupants. Therefore, a greater heating surface will be required. *Table 7* below shows the coefficients of reduction in radiance for installation heights of over 6 meters.

Tab. 7

H(m)	6	7	8	9	10	11	12	13	14	16	18	20
f_n	1,00	0,97	0,95	0,92	0,90	0,88	0,86	0,84	0,82	0,79	0,76	0,73

Example: in a warehouse where the panels are installed at a height of 10 meters, the number of panels obtained by dividing the total thermal requirement by the emission per meter of the selected model must then be divided by f_n = 0,9.

A specific evaluation should be made taking into consideration the size of the solid angles between the occupants of the room and the surfaces of all the panels installed. This is illustrated more clearly by the laws of thermal exchange means of by radiation. From our experience, and without entering into issues that are difficult to resolve which would involve factors of shape (fraction of the total radiant power which starts from one surface and reaches another one), we suggest this simple method:

a) calculate the cold surface of the external walls below the panels (perimeter x height of installation)
b) determine the ratio between this surface and the floor surface
c) if this ratio is greater than 1, the corrective coefficients for elevated heights are applied; if it is less than 1, they are not applied.

Panels supplied with water up to 120°C normally do not require the installation of side skirts.
These are found in systems which are used to heat single zones or where the thermal fluid is at a very high temperature.
For special installations, consult our technical department.

2.5 Corrective coefficient for inclined panels

EAE radiant panels can be installed at an inclination, following the geometry of the roof.
They can have either a transversal or longitudinal inclination.

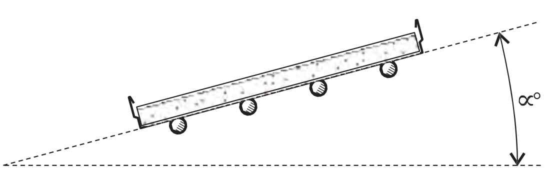


Fig.7 Transversally inclined panel

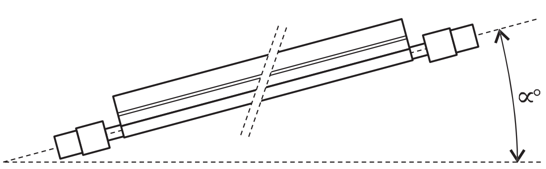


Fig.8 Longitudinally inclined panel

Inclination favours convective movement. There is an increase in total output, while output from radiance is decreased.
The new output value is determined by multiplying the thermal output in *Table 3* and *4* by the corrective coefficient shown in *Fig. 9*, based on the angle of inclination.

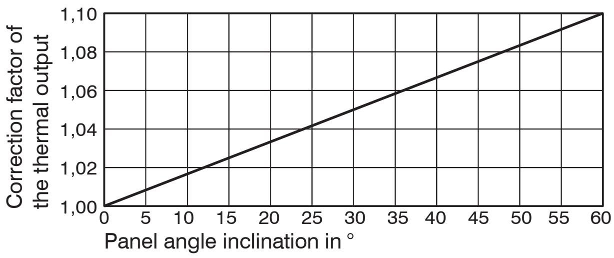


Fig.9 Corrective coefficient of emissions for inclined panels

2.6 Distance between radiant panels

To ensure a uniform distribution of heat, the distance between radiant panels must be equal to or less than their installation height.
The distance from the cold wall must not be greater than 1/3 of the height.

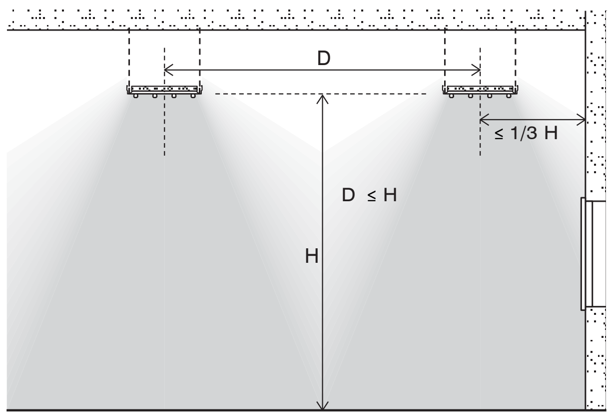


Fig.10 Distance between radiant panels

2.7 Minimum installation height

When making calculations for a radiant panel system, keep in mind that the required surface area of the panels decreases as the temperature of the thermal fluid increases.
In order to ensure comfort and well-being of individuals and prevent excessive radiation, limits must be set for the minimum height of panel installation.

Table 8 provides the minimum height of panel installation, based on the average temperature of the thermal fluid and the distance between tubes.

Tab.8 Minimum height of installation based on average temperature of thermal fluid

average temperature of water supply °C	distance between tubes 111 mm	distance between tubes 150 mm
	H min (m)	H min (m)
60	3,80	3,60
70	4,10	3,90
80	4,30	4,10
90	4,50	4,30
100	4,70	4,50
110	4,90	4,70
120	5,10	4,90

2.8 Positioning of ceiling mounted panels

When positioning and arranging the panels, it is advisable to comply with the following:

- if possible, install the panels parallel to the longest wall of the building
- keep a distance between the wall and the first panel that is not greater than a third of the installation height
- consider panels that are as long as possible, taking into account output and pressure drops
- chose the panel models, taking into account the installation height and the resulting area of radiation
- chose the panel models based on their thermal emission. Position models with greater output near the outer to walls to contrast cold radiation better
- check that the minimum height of installation is compatible with the temperature of the heating fluid being used. For installation at reduced height, choose panels that are narrower or that have a greater distance between tubes.

Figures 11, *12* and *13* clearly demonstrate how correct positioning of panels provides a uniform radiation and an ideal ambient temperature.

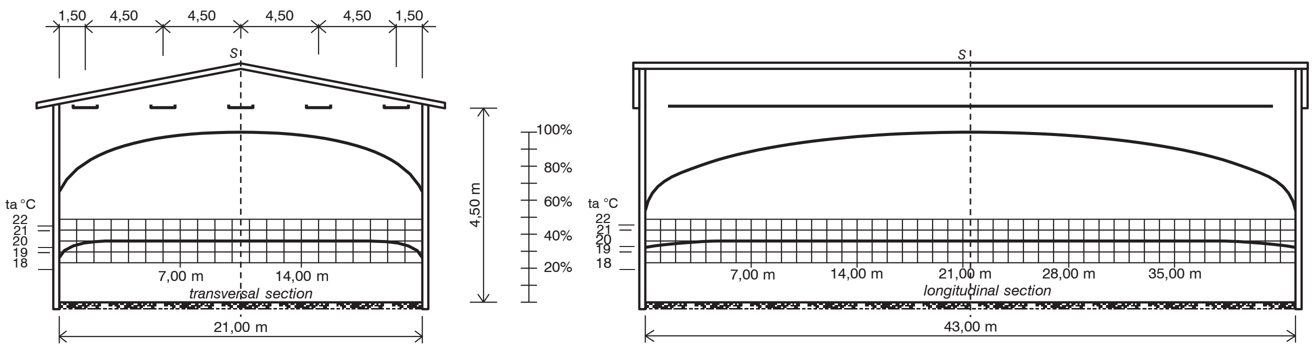


Fig.11 ***Intensity of radiation and ambient temperature with an equal distribution of panels which have the same emission and are positioned parallel to the longest side of the building***

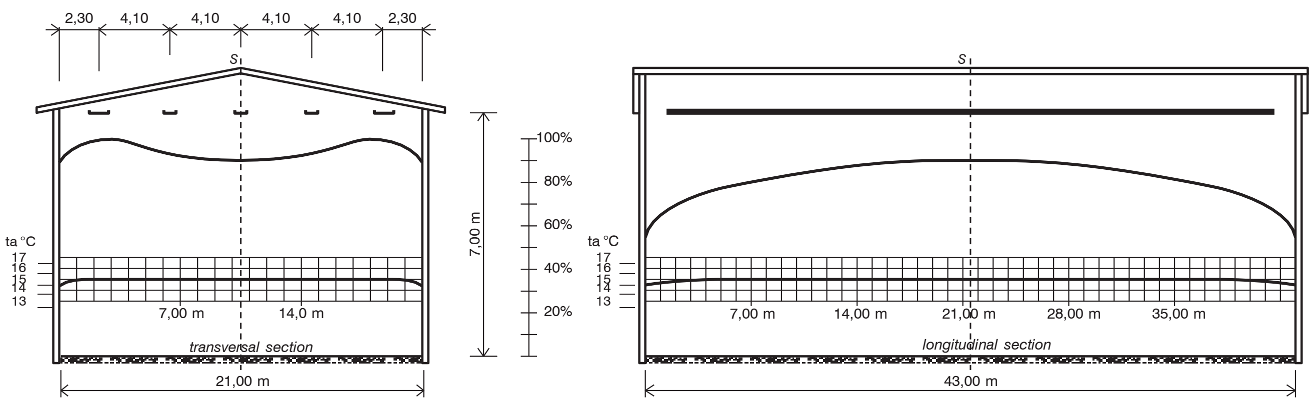


Fig.12 ***Intensity of radiation and ambient temperature and with panels which have a higher emission positioned nearer the external walls***

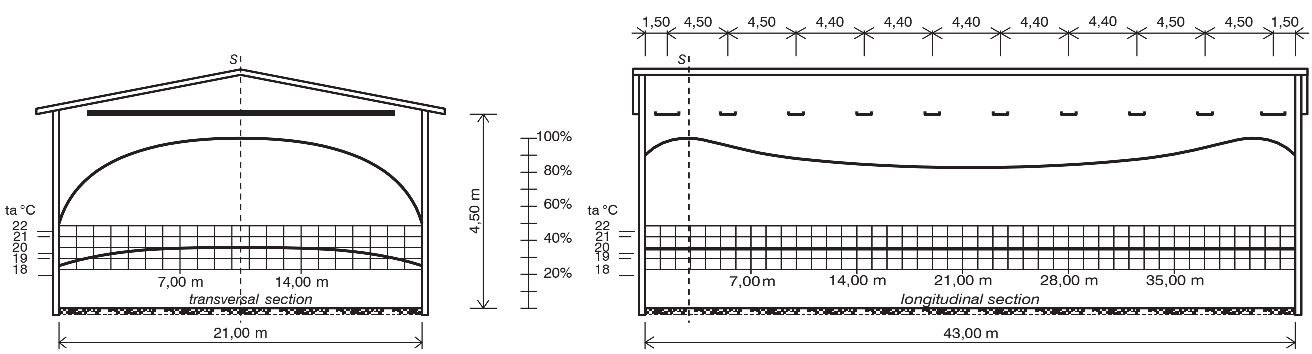


Fig.13 ***Intensity of radiation and ambient temperature with panels positioned parallel to the shortest wall of the Building***

2.9 Choosing the right model: calculations of radiant panels

While respecting the structural needs of the building and the layout of any scaffolding, machinery, and so on, it is always advisable to place the radiant panels parallel to the longest wall.
In this, if you position panels of greater length the number of panels it thus reduced, therefore you will also reduce the thermal fluid distribution network, resulting in lower system costs.
The panels length and layout must be such that it evenly covers the entire area to be heated.

In the following examples, we have hypothesized similar rooms but with different panel heights, or with different panel layouts.

First example (*Fig. 11 and 14*)
Consider a warehouse with the following dimensions: 43 x 21 meters with average height of 5,5 meters, for a volume of approximately 4967 m³.

The thermal requirement has been estimated at 95 kW.
Ambient temperature $t_a = 20\,°C$.
Panel installation height of the 4,5 m.
Maximum distance between panels 4,5 m.

Consider 5 panels with a length of 40 m, positioned as in *Fig. 14*, for a total length of 200 m.

Dividing the thermal requirement by the total length of the panels gives the thermal emission per metre:

95000 W / 200 m = 475 W/m

Choosing settings:
Water supply temperature $t_1 = 80\ °C$
Water return temperature $t_2 = 70\ °C$
the average temperature of the water will be:

$$t_m = \frac{t_1 + t_2}{2} = \frac{80+70}{2} = 75\,°C$$

and the ΔT is: $\Delta T = t_m - t_a = 75°C - 20°C = 55°C$

From *Table 3* with ΔT = 55 °C and considering model 8/100-½", thermal emission of 516 W/m is obtained.

The total installed thermal power is:
200 m x 516 W/m = 103200W
this value provided is sufficient to cover thermal requirement.
Having a distribution of only 5 connections to balance the circuit, it is advisable to use calibration valves on the panels.

Second example (*Fig. 12 and 15*)
Consider a warehouse with the same previous dimensions: 43 x 21 meters with average height of 8,2 meters, for a volume of approximately 7405 m³.

The thermal requirement has been estimated at about 120 kW.
Ambient temperature $t_a = 15\ °C$.
Panel installation height 7 m.
Maximum distance between panels 7 m.

Consider 5 panels with a length of 40 m, positioned as in *Fig. 15*, for a total length of 200 m.
As previously mentioned in *paragraph 2.4*, it is not necessary to increase the number of panels to be installed.

Dividing the thermal requirement by the total length of the panels provides the average thermal emission per meter:

120000 W / 200 m = 600 W / m

Choosing settings:
Water supply temperature $t_1 = 80\ °C$
Water return temperature $t_2 = 70\ °C$
the average temperature of the water will be:

$$t_m = \frac{t_1 + t_2}{2} = \frac{80+70}{2} = 75\,°C$$

and the ΔT is: $\Delta T = t_m - t_a = 75\,°C - 15\,°C = 60\,°C$

Positioned laterally, there are 2 panels model 10/100-½" with a length of 40 meters (80 m total). Positioned centrally there are 3 panels model 8/100-½" with a length of 40 meters (120 m total).

Table 3 provides with ΔT = 60 °C a thermal emission of:

683 W/m for panels of 10/100-½"

572 W/m for panels of 8/100-½"

The total thermal emission of the single models is:
80m x 683W/m = 54640W

120m x 572W/m = 68640W

for a total of:
54640 + 68640 = 123280 W
this value provided is sufficient to cover the 120 kW required.
Having a distribution of only 5 connections to balance the circuit, it is advisable to use calibration valves on the panels.

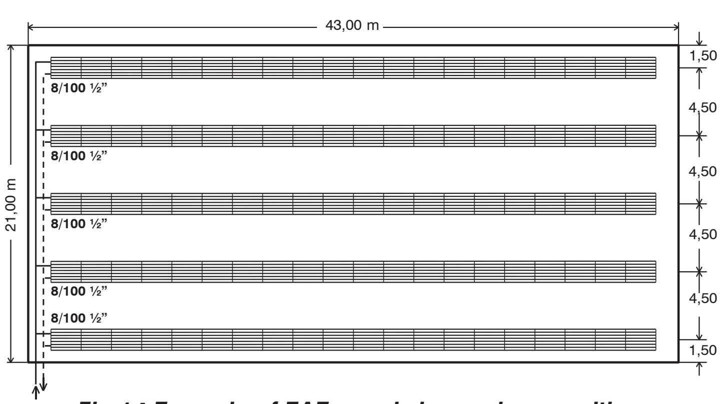


Fig.14 Example of EAE panels in warehouse with average height of 5,5 m and parallel panels on the longest side

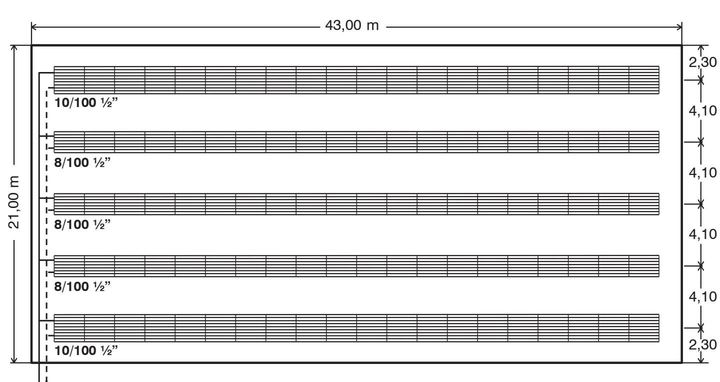


Fig.15 Example of EAE panels in warehouse with average height of 5,5 m and parallel panels on the longest side

Third example (*Fig. 13 and 16*)

Consider a warehouse, again with the same dimensions: 43 x 21 meters with average height of 5,5 meters, for a volume of approximately 4967 m^3.
The thermal requirement has been estimated as about 95 kW.
Ambient temperature $t_a = 20\,°C$.
Panel installation height 4,5 m.
Maximum distance between radiant panels 4,5 m.

In the eventuality that it is not possible to position the panels parallel to the longer wall of the warehouse, then they need to be positioned parallel to the shorter wall. Consider 10 panels with a length of 18 m, arranged as in *Fig. 16*, for a total length of 180 m.

Dividing the thermal requirement by the length gives the average thermal emission per meter:

$$95000\,W / 180\,m = 528\,W/m$$

Choosing settings:
Water supply temperature $t_1 = 80\,°C$
Water return temperature $t_2 = 70\,°C$
the average temperature of the water will be:

$$t_m = \frac{t_1 + t_2}{2} = \frac{80+70}{2} = 75\,°C$$

And the ΔT is: $\Delta T = t_m - t_a = 75°C - 20°C = 55°C$

Positioned laterally there are 2 panels model 10/100-½" with a length of 18 meters (36 m total) and in the center there are 8 panels model 8/100-½" with a length of 18 meters (144 m total).

Table 3 provides with $\Delta T = 55\,°C$ a thermal emission of:

616 W/m for panels 10/100-½"

516 W/m for panels 8/100-½"

The total thermal power of the single models is:

$$36\,m \times 616\,W/m = 22176\,W$$
$$144\,m \times 516\,W/m = 74304\,W$$

for a total of:

$$22176 + 74304 = 96480\,W$$

Thermal power sufficient to cover thermal requirement. Having a distribution of 10 connections and short panels, the circuit can be balanced using "inverse return".

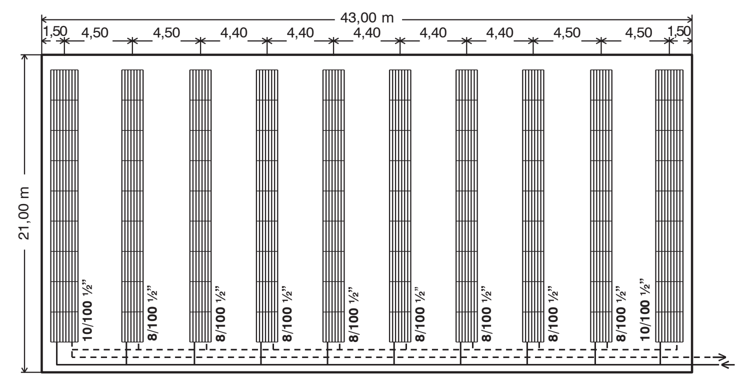


Fig.16 Example of EAE panels in warehouse with average height of 5,5 m and parallel panels on the shortest side

2.10 Effects on luminosity originating from the ceiling covering

Correctly positioned, ceiling mounted panels do not reduce the light from skylights in the roof.
The effects on luminosity have been verified both before and after the installation of the panels, in many applications the reduction of light in the warehouses was negligible.

2.11 Use of panels in cooling systems

Currently not available, under development.

2.12 Diagrams of system balancing and power supply

Radiant panels supplied by hot water can be connected to the distribution network with inlet and outlet of the fluid on opposite sides (type A headers) or with connections on the same side (type AA and B headers).

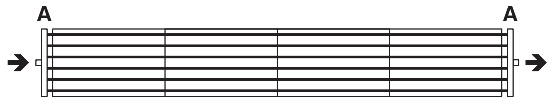


Fig.17 Connection with fluid inlet and outlet on opposite side

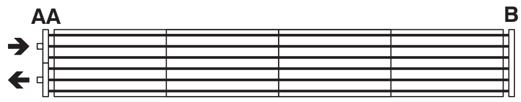


Fig.18 Connection with fluid inlet and outlet on same side

In the first case, all the panel tubes are supplied in parallel and the water flow is divided equally among them. In the second case, half the tubes are connected in series with the other half, thus doubling the flow rate of each tube.
The following are some examples of possible supply layouts.

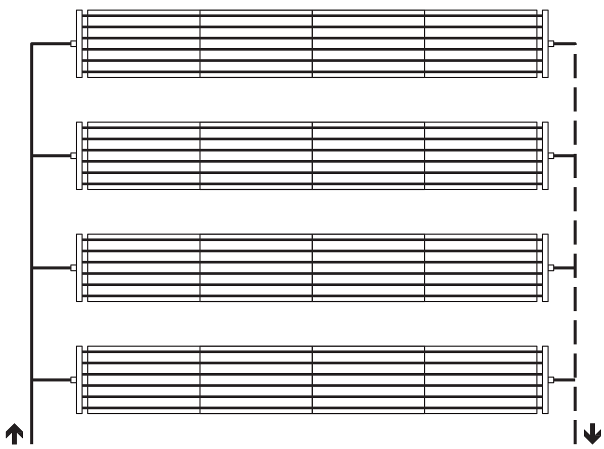


Fig.19 EAE radiant panels in parallel with opposite connections

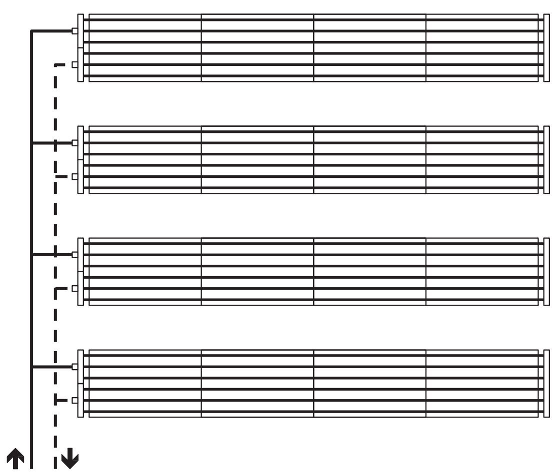


Fig.20 EAE radiant panels in parallel with same side connections

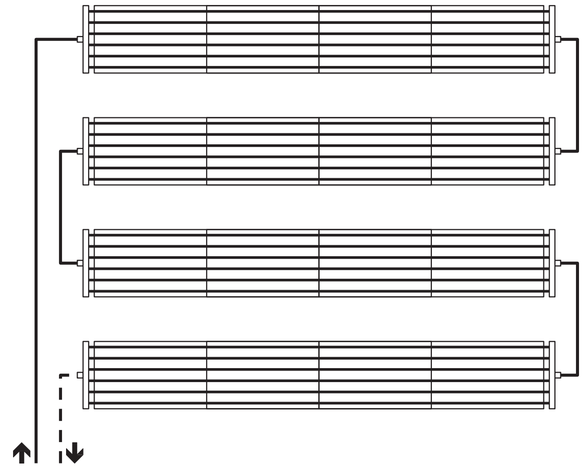


Fig.21 EAE radiant panels in series with opposite connections

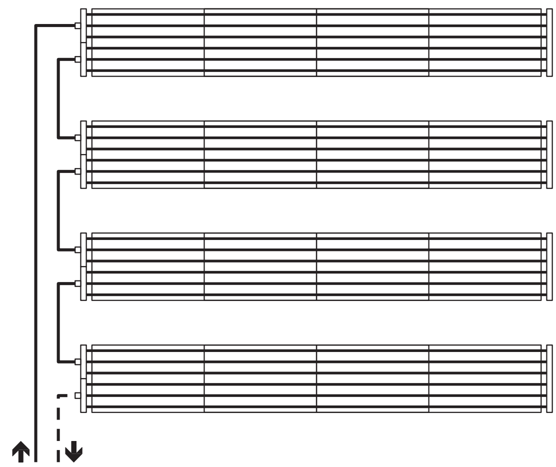
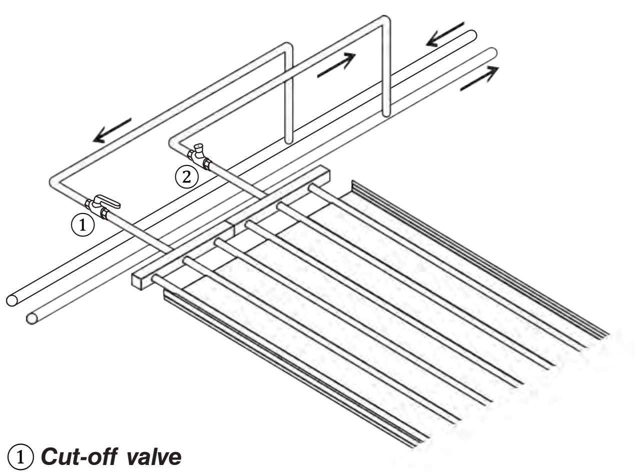


Fig.22 EAE radiant panels in series with same side connections

In any heating system, it is important that the heating elements are supplied with the proper amount of fluid as calculated during the systems' design phase.
The radiant panels must also be applied in a perfectly balanced manner.
To balance, provide calibration valves must be used where necessary and are to be adjusted at start-up.



① ***Cut-off valve***

② ***Cut-off and balancing***

If there are many panels, it is advisable to provide a set of tubes for the "inverse return" (*Fig. 23 and 24*) which balances the system. This solution is expensive and it is not always feasible.

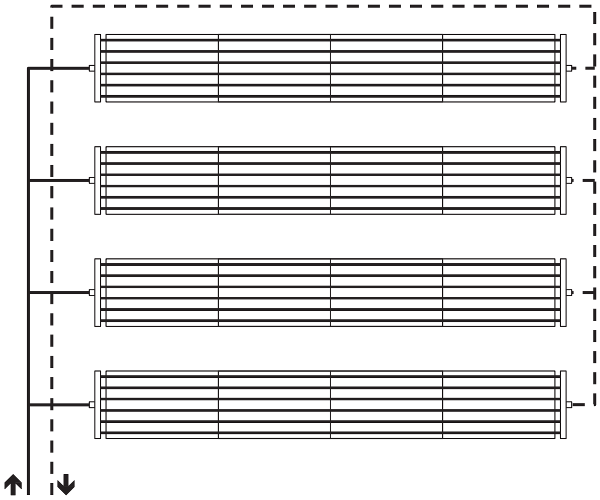


Fig.23 EAE radiant panels with opposite connections and with "inverse return" tubes

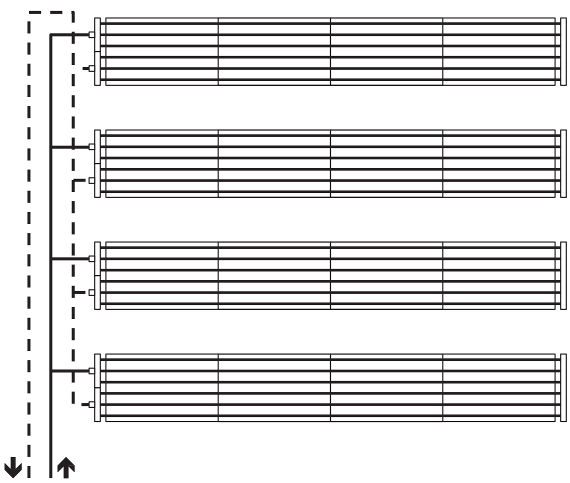


Fig.24 EAE radiant panels with same-side connections and with "inverse return" pipes

2.13 Flow rate and speed of water in the panels

If the speed of the water panel tubes of the panels is too low, the water will not be able draw off the air. This may cause a shutdown in circulation with a substantial reduction in the output of the panel.
During the design of the systems, it is advisable to make sure that the speed of the water in each single tube is never less than 0,23 m/s in tubes of ½” and 0,32 m/s in tubes of¾”.
In hot water radiating panels, it is advisable to have a temperature difference of 10°C between the supply and return headers. This is considered an acceptable compromise between the size of the network and the need for a high surface temperature.
Also, pressure drops may be considered acceptable in panel tubes which do not exceed 200 - 250 Pa/m.

2.14 Panel tube pressure drops

Table 9 shows the values of the pressure drop in Pa/m and of the speed in m/s based on the water flow rate of each tube in a panel, with an average water temperature of 75 °C.
This is true both for panels with electro-welded tubes and for those with tubes without welding.

Tab.9 Pressure drop in tubes in EAE expressed in Pa/m

	Electro-welded tubes				Tubes without welding			
	½”		¾”		½”		¾”	
Water flow rate l/h	Pressure drop in Pa/m	Speed m/s	Pressure drop in Pa/m	Speed m/s	Pressure drop in Pa/m	Speed m/s	Pressure drop in Pa/m	Speed m/s
200	41	0,21			70	0,25		
220	49	0,23			85	0,28		
240	57	0,25			100	0,31		
260	66	0,28			115	0,33		
280	75	0,30			129	0,36		
300	86	0,32			150	0,39		
320	96	0,34			165	0,41		
340	108	0,36	31	0,22	190	0,44	45	0,25
360	119	0,38	35	0,23	200	0,46	50	0,26
380	132	0,40	38	0,24	220	0,49	55	0,28
400	145	0,42	42	0,25	250	0,51	60	0,29
420	159	0,45	46	0,27	270	0,54	65	0,31
440	173	0,47	50	0,28	295	0,57	70	0,32
460	188	0,49	54	0,29	340	0,61	76	0,33
480	203	0,51	58	0,30	350	0,62	82	0,35
500	219	0,53	62	0,32	360	0,66	90	0,36
550	262	0,58	73	0,35	450	0,71	110	0,40
600	309	0,64	86	0,38	525	0,77	130	0,44
650			100	0,41			150	0,47
700			114	0,44			170	0,51
750			130	0,48			195	0,54
800			146	0,51			220	0,58
850			164	0,54			250	0,62
900			182	0,57			275	0,65
950			202	0,60			300	0,69
1000			222	0,64			350	0,75
1100			266	0,70			400	0,80
1200			313	0,76			455	0,88
1300			364	0,83			550	0,95
1400			420	0,88			640	1,04

For average water temperatures different from 75 °C, the values in *Table 9* must be calculated, applying the coefficients shown in *Table 10*.

Tab.10 Coefficients for average water temperatures different from 75 °C

Temperature	40°C	60°C	90°C	120°C	140°C
Coefficient	1,18	1,06	0,96	0,91	0,87

2.15 Header pressure drops

Table 11 and *12* show the pressure drops in a pair of headers based on their water flow rate, the type of supply (same-side or opposite) and the diameter of the tubes (½” or ¾”).

Tab.11 Pressure drop in Pa of a PAIR OF HEADERS - TUBES ½”

Total flow rate of headers l / h	**Pressure drop in pair of headers A Opposite sides** *number of tubes per panel*									**Pressure drops in pair of headers AA-B - Same side** *number of tubes per panel*			
	2	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*4*	*6*	*8*	*10*
400	110									240	140		
500	170	100								380	220		
600	240	150	100							540	310	210	
700	320	200	140	110						730	420	290	220
800	420	250	180	140	120	100				960	550	380	280
900	530	320	230	180	150	130	110			1210	690	480	360
1000	650	400	280	220	180	160	140	120	110	1500	850	580	440
1200	940	560	410	320	260	230	200	180	160	2150	1230	840	640
1400	1270	770	550	430	360	300	270	240	220	3000	1670	1150	870
1600	1660	1000	720	560	460	400	350	310	280		2200	1500	1150
1800	2100	1270	910	710	590	500	440	390	350		2800	1900	1450
2000		1560	1120	880	720	620	540	480	440		3400	2350	1800
2250		2000	1420	1100	910	800	680	610	550			3000	2300
2500			1750	1370	1130	980	840	750	680			3700	2800
2750			2100	1650	1360	1200	1050	910	830			4400	3400
3000				2000	1630	1400	1250	1080	980				4000
3500				2700	2200	1900	1650	1500	1350				5400
4000					2900	2500	2150	1950	1750				
4500						3200	2800	2500	2200				
5000						3900	3400	3000	2800				
5500							4100	3700	3300				
6000								4400	3900				
7000									5400				

Tab.12 Pressure drop in Pa of a PAIR OF HEADERS - TUBES ¾”

Total flow rate of headers l / h	**Pressure drops in pair of headers A - Opposite sides** *number of tubes per panel*					**Pressure drops in pair of headers AA-B - Same side** *number of tubes per panel*			
	2	*4*	*6*	*8*	*10*	*4*	*6*	*8*	*10*
800						320			
900	180					400	240		
1000	220	100				500	290	210	
1200	320	150	100			710	420	300	230
1400	440	200	140	110		970	570	400	310
1600	570	260	180	140	120	1300	740	530	410
1800	720	330	230	180	150	1600	940	660	520
2000	890	410	280	220	190	2000	1200	840	640
2250	1150	520	350	280	240	2500	1500	1050	800
2500	1400	640	430	340	290	3100	1800	1300	1000
2750	1700	770	530	420	350	3800	2200	1550	1200
3000	2000	920	630	490	420	4500	2600	1850	1450
3500	2700	1300	850	670	570		3600	2500	1950
4000	3600	1650	1100	870	740		4700	3300	2550
4500		2100	1400	1100	940			4200	3200
5000		2600	1750	1400	1150			5100	4000
5500		3100	2100	1700	1400			6200	4800
6000			2500	2000	1700				5700
7000			3400	2700	2300				7800
8000			4450	3500	3000				
9000				4400	3800				
10000				5500	4600				
12000					6700				

2.16 Calculation of panel pressure drop

To determine the pressure drop of a radiant panel, you need to add the pressure drop of the tubes to that of the headers, using the data provided in *paragraphs 2.14* and *2.15*.

Here are a few examples.

First example

Consider a radiant panel model 8/100 with a length of 42 meters (*Fig. 25*) with electro-welded tubes of ½" and with opposite connections (type A headers).

Water supply temperature	t_1	=	85 °C
Water return temperature	t_2	=	75 °C
Ambient temperature	t_a	=	15 °C

$$\Delta T = \frac{t_1 + t_2}{2} - t_a = t_m - t_a = 65\,°C$$

With this data, *Table 3* shows that the thermal output per meter of the panel is:

$$\Phi_m = 628\ W/m$$

The total thermal output of the panel with a length of 42 meters is therefore:

$$\Phi_p = 628\ W/m \times 42\ m = 26376\ W$$

and its water flow rate:

$$Q_p = \frac{\Phi_p \times 0{,}86}{t_1 - t_2} = \frac{26376 \times 0{,}86}{10} = 2268\ kg/h$$

Since the panel has 8 tubes and opposite connections, the inlet water is equally divided among all 8 tubes, and so the water flow rate of each pipe is:

$$Q_t = \frac{Q_p}{8} = \frac{2268}{8} = 283\ kg/h = 283\ l/h$$

this is a higher value than the suggested minimum flow rate in a tube of ½" (220 l/h).

Table 9 shows that the pressure drop in the tubes is more or less 76 Pa/m.
Therefore, the total pressure drop in the tubes is:

$$\Delta p_t = 42\ m \times 76\ Pa/m = 392\ Pa$$

Using *Table 11,* in correspondence with the total flow rate of the panel, which is about 2268 l/h, it is possible to evaluate that the pressure drop in the pair of headers Δp_c is 693 Pa.

The pressure drop of the panel will be the sum of the two values, therefore:

$$\Delta p_p = \Delta p_t + \Delta p_c = 3192 + 6693 = 3885\ Pa$$
(equal to 0.39 m c. A.)

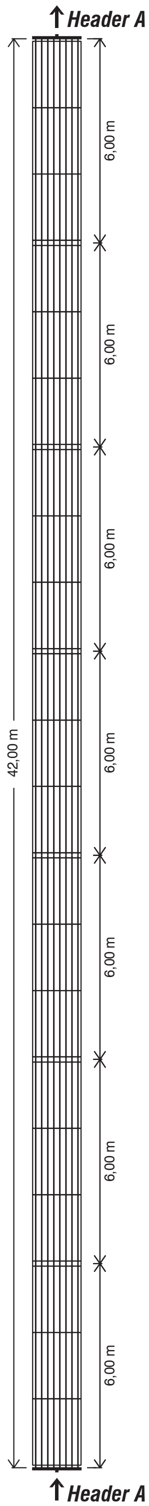


Fig.25

Second example

Consider a radiant panel model 10/100 with a length of 42 meter (*Fig. 26*) with electro-welded tubes of ½" and with same-side connections (type AA and B headers).

Water supply temperature	t_1	=	85 °C
Water return temperature	t_2	=	75 °C
Ambient temperature	t_a	=	15 °C

$$\Delta T = \frac{t_1 + t_2}{2} - t_a = t_m - t_a = 65\,°C$$

With this data, *Table 3* shows that the thermal output per meter of the panel is:

$$\Phi_m = 751\ W/m$$

The total thermal output of the panel with a length of 42 meters, is therefore:

$$\Phi_p = 751\ W/m \times 42\ m = 31542\ W$$

and its water flow rate:

$$Q_p = \frac{\Phi_f \times 0{,}86}{t_1 - t_2} = \frac{31542 \times 0{,}86}{10} = 2713\ kg/h$$

Since the AA header has a diaphragm in it, the water supply is divided among 5 tubes.
Therefore, the flow rate of each tube is:

$$Q_t = \frac{Q_p}{5} = \frac{2713}{5} = 543\ kg/h = 543\ l/h$$

the above mentioned value is higher than the suggested minimum flow rate in a tube of ½" (220 l/h).

Table 9 shows that the pressure drop in the tubes is roughly 256 Pa/m.
Therefore, the total pressure drop in the tubes is:

$$\Delta p_t = 42\ m \times 2 \times 256\ Pa/m = 21504\ Pa$$

In *Table 11*, under the total flow rate of the panel, which is about 2713 l/h, it is possible to evaluate that the pressure drop in the pair of headers Δp_c is about 3320 Pa.

The pressure drop of the panel will be the sum of the two values, therefore:

$$\Delta p_p = \Delta p_t + \Delta p_c = 21504 + 3320 = 24824\ Pa$$
(equal to 2.53 m c. a.)

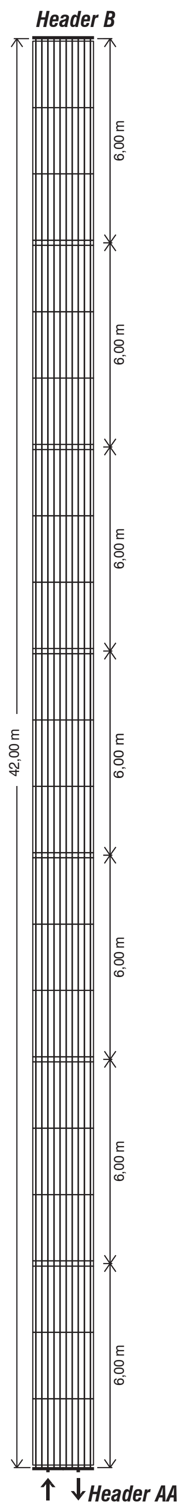


Fig.26

Third example

Consider a radiant panel model 10/100 with a length of 84 meters (*Fig.27*) with electro-welded tubes of ¾” and with same-side connections (type AA and B headers).

Water supply temperature	t_1	=	85 °C
Water return temperature	t_2	=	70 °C
Ambient temperature	t_a	=	15 °C

$$\Delta T = \frac{t_1 + t_2}{2} - t_a = t_m - t_a = 62{,}5\,°C$$

With this data, *table 4* shows that the thermal output per meter of the panel is:

$$\Phi_m = 756\ W/m$$

The total thermal output of the panel 84 meters long, is therefore:

$$\Phi_p = 756\ W/m \times 84\ m = 63504\ W$$

and its water flow rate:

$$Q_p = \frac{\Phi_p \times 0{,}86}{t_1 - t_2} = \frac{63\,504 \times 0{,}86}{15} = 3\,640\ kg/h$$

Since the AA headers has a diaphragm in it, the supply water is divided among 5 tubes. Therefore, the flow rate of each tube is:

$$Q_t = \frac{Q_p}{5} = \frac{3\,640}{5} = 728\ kg/h = 728\ l/h$$

the above mentioned value is higher than the suggested minimum flow rate in a tube of ¾” (500 l/h).

Table 9 shows that the pressure drop in the tubes is 123 Pa/m.
Therefore, the total pressure drop in the tubes is:

$$\Delta p_t = 84\ m \times 2 \times 123\ Pa/m = 20664\ Pa$$

In *table 12*, under the total flow rate of the panel, which is about 3640 l/h, it is possible to evaluate that the pressure drop in the pair of headers Δp_c is about 2120 Pa.

The pressure drop of the panel will be the sum of the two values, therefore:

$$\Delta p_P = \Delta p_t + \Delta p_c = 20664 + 2120 = 22784\ Pa$$

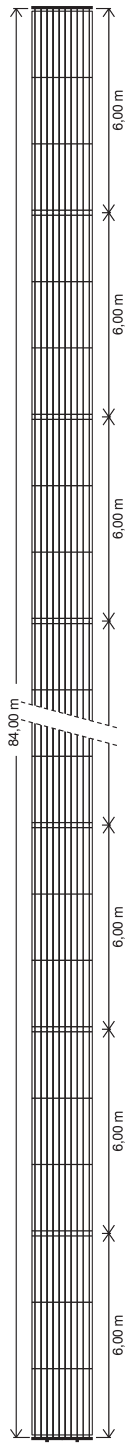


Fig.27

2.17 Head and flow rate of the electric pump

In a circuit of radiant panels, the flow rate of the electric pump is determined from the sum of the flow rates of the single panels of the circuit. Its static pressure is obtained by adding the pressure drops of the least favored radiant panel, any cut-off and calibration valves on the connection of that panel, the tubes that supply it and the heating plant.

Consider, for example, the need to heat a warehouse measuring 90 x 60 meters, 9 meters high, where the panels have been installed at a height of 8 meters.

1st solution

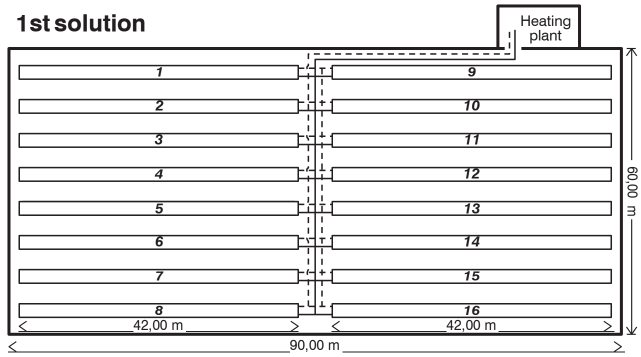


Fig.28

16 panels model 10/100-½” 42 meters long have been adopted.

Taking as valid the conditions described in the second example of the previous paragraph, a panel 10/100-½” 42 meters long has a pressure drop of about 2,53 m c.a. and a flow rate of 2713 l/h. The least favored panel will be number 8 (or number 16).

2nd solution

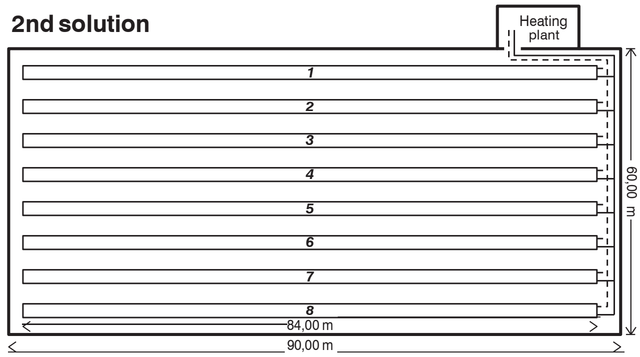


Fig.29

8 panels model 10/100-¾” 84 meters long have been adopted.

Taking as valid the conditions described in the third example of the previous paragraph, a panel 10/100-¾” 84 meters long has a pressure drop of about 2,32 m c.a. and a flow rate of 3640 l/h.
The least favored panel will be number 8.

Obviously, the second solution is more rational and advantageous, for the following reasons:

- since the number of connections is limited, there is no need for "inverse return". For balancing of the circuit, it is possible to use only a few calibration valves.
- the use of panels with tubes of ¾” allows for the realization of longer panels with modest pressure drops.
  In this example, the ¾” panel has a greater output than the ½” panel. Therefore, with the same power installed power (about 500 kW) a greater temperature difference can be used (85 °C - 70 °C instead of 85 °C - 75 °C). This will provide a flow rate of 29 m^3/h as opposed to the 43 m^3/h required by panels with tubes of ½”.
  Therefore, with the same power installed and pressure drops, there is reduced flow rate, which means smaller tube diameters and reduced power of the electric pump.

All this leads to a reduction in the amount of tubes required distribution which therefore results in substantial savings.

2.18 Controls

Since this system has low thermal inertia, the ambient temperature can be controlled in a variety of ways, depending on the type and importance of the system. However, you should keep in mind that with ceiling mounted radiant panel systems, changes regulations should be in made to the temperature of the water delivered to the panels. The water flow rate should be kept constant. *"Turning* the panels *on and off"* may create unpleasant sensations (like moving from the sunshine into shade). This is because blocking circulation means blocking the beneficial effect of radiation.
It is therefore advisable to use a three-ways valve, controller and ambient probes as shown in *diagram 1*. The three-ways valve mixes the water to be sent to the panels so as to maintain the desired ambient temperature.
Normal ambient probes can be installed to measure the air temperature. Nowadays the market also provides probes that directly measure the operating temperature. Thanks to the rapid start up of the system which reduces operating costs, it is advisable install a timer for daily and weekly shutdowns. In this case we also suggest to include an anti-freeze function.

In panel systems of a certain size (warehouses of over 10000 m^2) in which operating costs are substantial, controls system should be completed with an outdoor probe. However, this probe must never limit the operation of the ambient probe (*diagram 2*).

In the case of cost reduction in large-scale industrial plants, it is necessary to use a controlled, programmable regulation (*diagram 3*).

Diagram 1

Adjustment of delivery hot water temperature based on ambient temperature, timer and anti-freeze function for start-up if the ambient temperature drops below a certain value during shutdown.

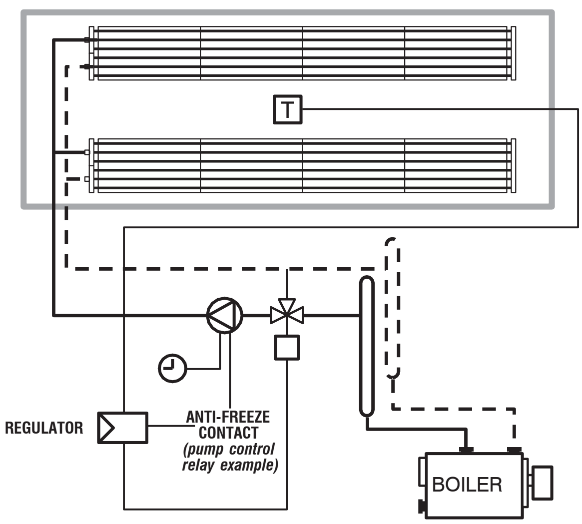


Fig. 30

Diagram 2

Control of hot water supply temperature based on outdoor temperature with correction made by ambient temperature, programmable timer for weekly or night-time shutdown with anti-freeze function which must be activated in the eventuality that the ambient temperature, during shutdown, drops below a certain value (anti-freeze contact wiring parallel to the system on/off switch)

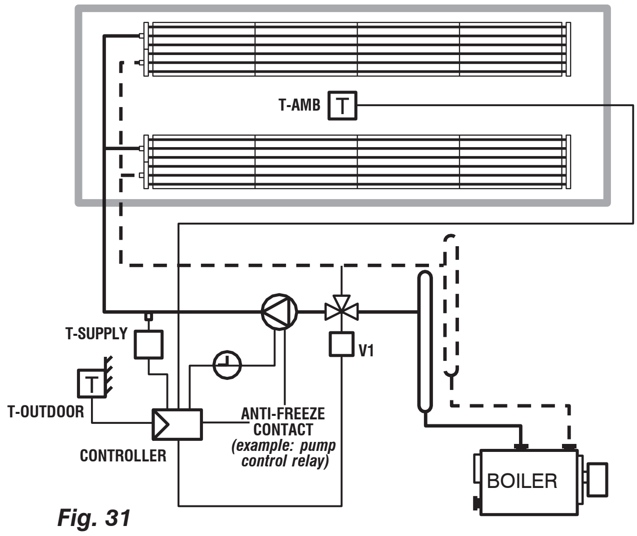


Fig. 31

Diagram 3

Control for systems with variation of the programmed pre-heating hours based on the external temperature, which ensures in any condition the desired ambient temperature with night-time and holiday shutdowns. Regulations and controls of the temperature difference of the water and of the operating temperature.

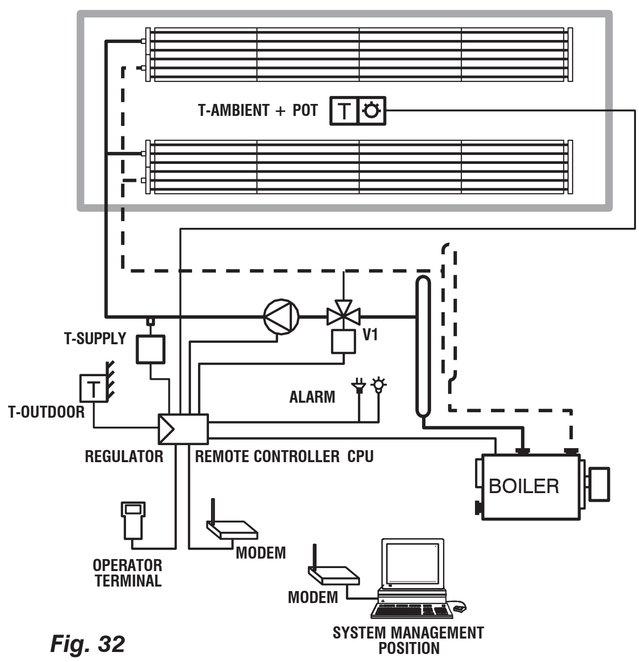


Fig. 32

If the system includes a series of rooms all with the same characteristics, it is possible to use a single three-ways valve with various ambient probes.
If instead it is necessary to heat rooms that do not have the same characteristics, it will be necessary to foresee several independently controlled circuits.

2.19 Methods of installation and dilation

After installing the suspension ties on the ceiling, the panels are lifted and hooked onto the brackets on the panels.
The fastening brackets are positioned on the panels at a distance of about 95 cm from one another (see *Fig. 2*). Normally, panels are hooked on every two meters. The following are examples of the distance between suspension points, creating only 6 meter modules (*Fig. 33*) and 6 and 4 meter modules (*Fig. 34*).

It is indispensable that the fastening system that is used allows adjustment in height of the ties so as to perfectly straighten the installation without bends.

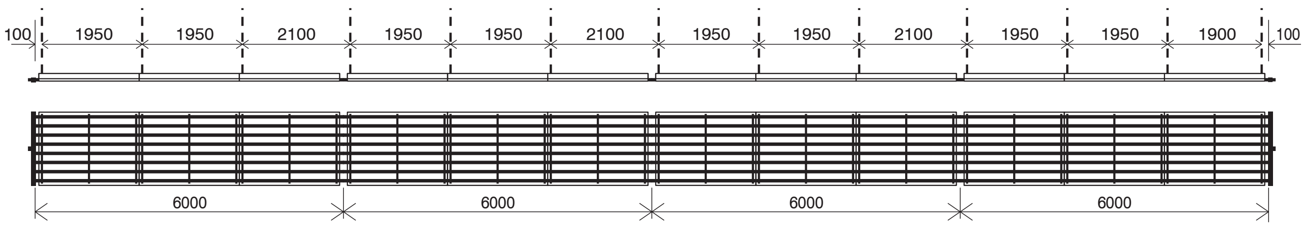


Fig.33 Example of distance between suspension points 6 metres modules

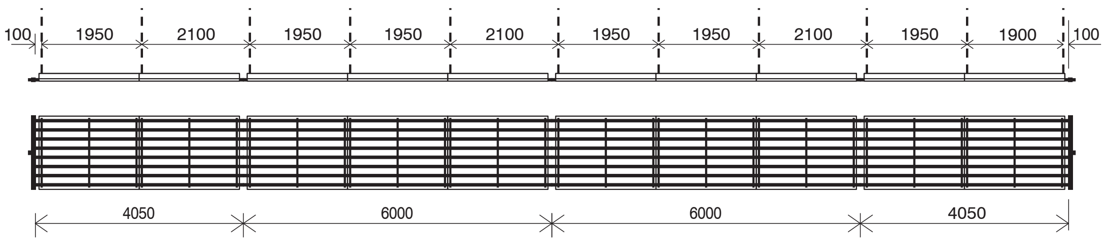


Fig.34 Example of distance between suspension points 4 and 6 metre modules

While functioning, radiant panels behave in general like all tubes do when they have hot liquids flowing through them. Therefore they undergo varying amounts of dilation depending on their length and the temperature of the liquid. It is important that the suspension ties are long enough so that they do not prevent the panels from dilating (*Fig. 35* and *Table 13*).

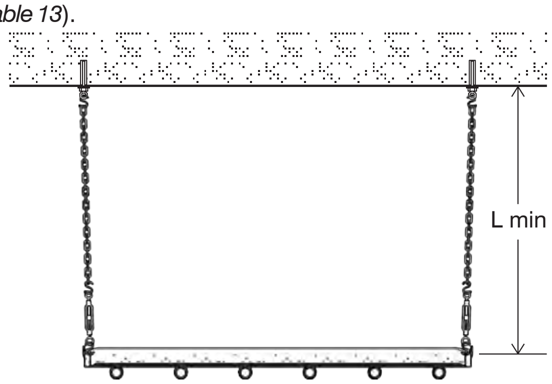


Fig.35 Minimum length of suspension ties

Table 13 shows the minimum length of the ties based on the length of the panel and the difference between the average temperature of the heating fluid and the ambient temperature.

Tab.13 Minimum length of suspension ties *(mm)*

Length of panels (m)	Temperature difference (T_m-T_a)				
	75 °C	100 °C	125 °C	150 °C	175 °C
25	150	200	250	300	350
50	300	400	450	550	650
75	450	550	700	850	1000
100	550	750	950	1100	1300
150	850	1100	1400	1650	1950
200	1100	1500	1900	2200	2600

If ties of a sufficient length cannot be provided, it will be necessary to provide rigid supports with sliding rollers (*Fig. 36*).

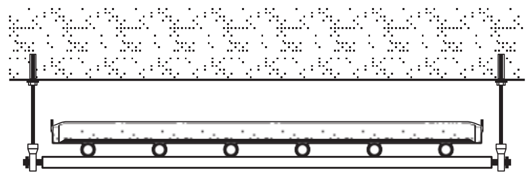


Fig.36 Example of brackets with rollers

To avoid placing too much stress on the radiant panels, the connection tubes between the headers and the distribution network must be shaped in a way so as to absorb the dilation that takes place within the system.

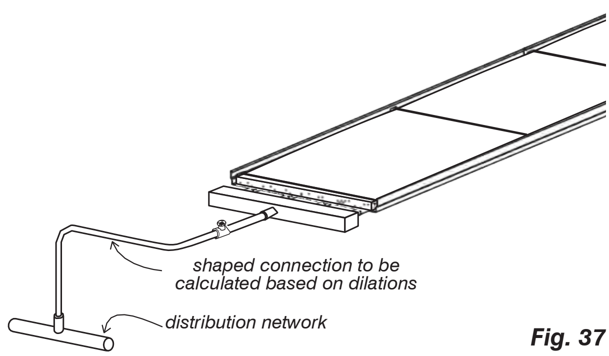


Fig. 37

To make air venting easier, the headers include threaded inserts of 3/8" for the installation of automatic vent valves.

2.20 Examples of ceiling fastenings

This manual provides useful information regarding the technical data of this product.

The following drawings show some examples of suspension systems for radiant panels.

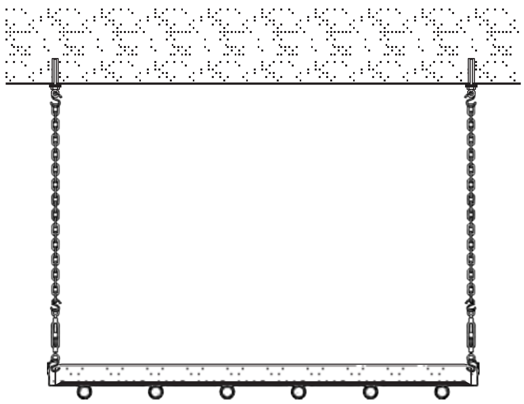


Fig.38 Example of brackets with chains

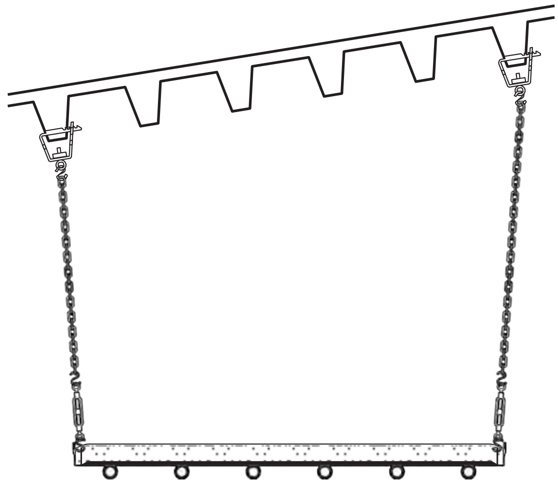


Fig.41 Example of brackets on ribbed sheeting

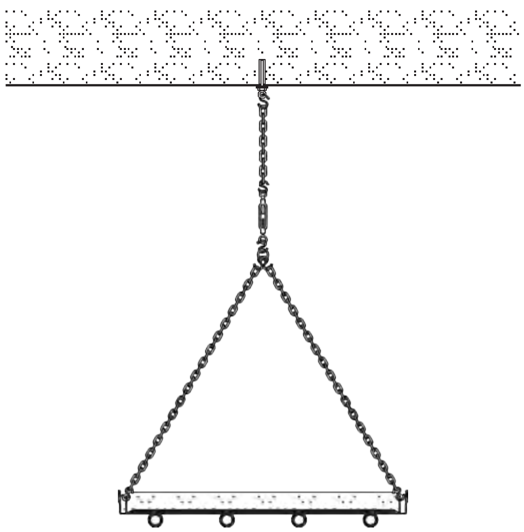


Fig.39 Example of brackets with chains

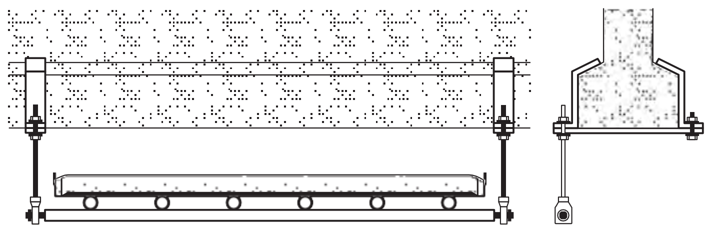


Fig.42 Example of brackets with roller for panels prefabricated roofing

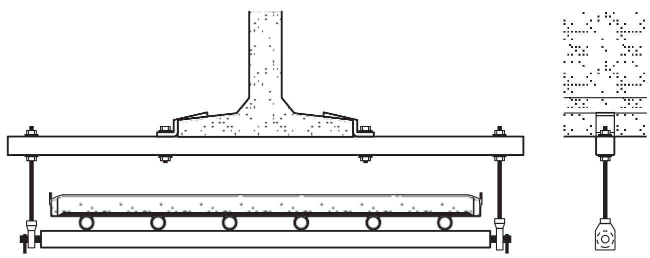


Fig.43 Example of brackets with roller for panels parallel to prefabricated roofing

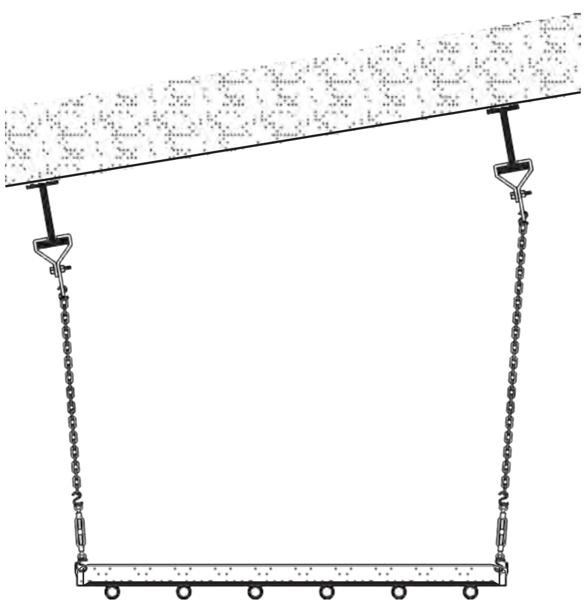


Fig.40 Example of brackets hooked onto metal beams

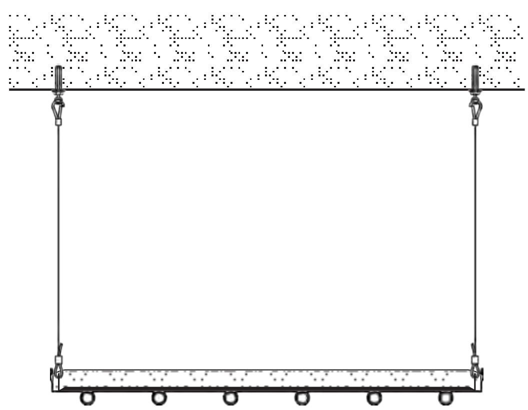


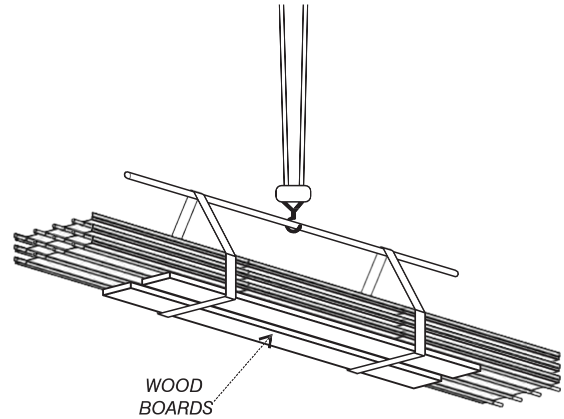
Fig.44 Example of brackets with steel ties

2.21 Packaging

The panels are normally shipped stacked as packs of about 10 pieces, strapped and placed on suitable wood spacer pallets.
Protective strips of polyethylene are placed between the panels near the brackets.
Special packaging on request.

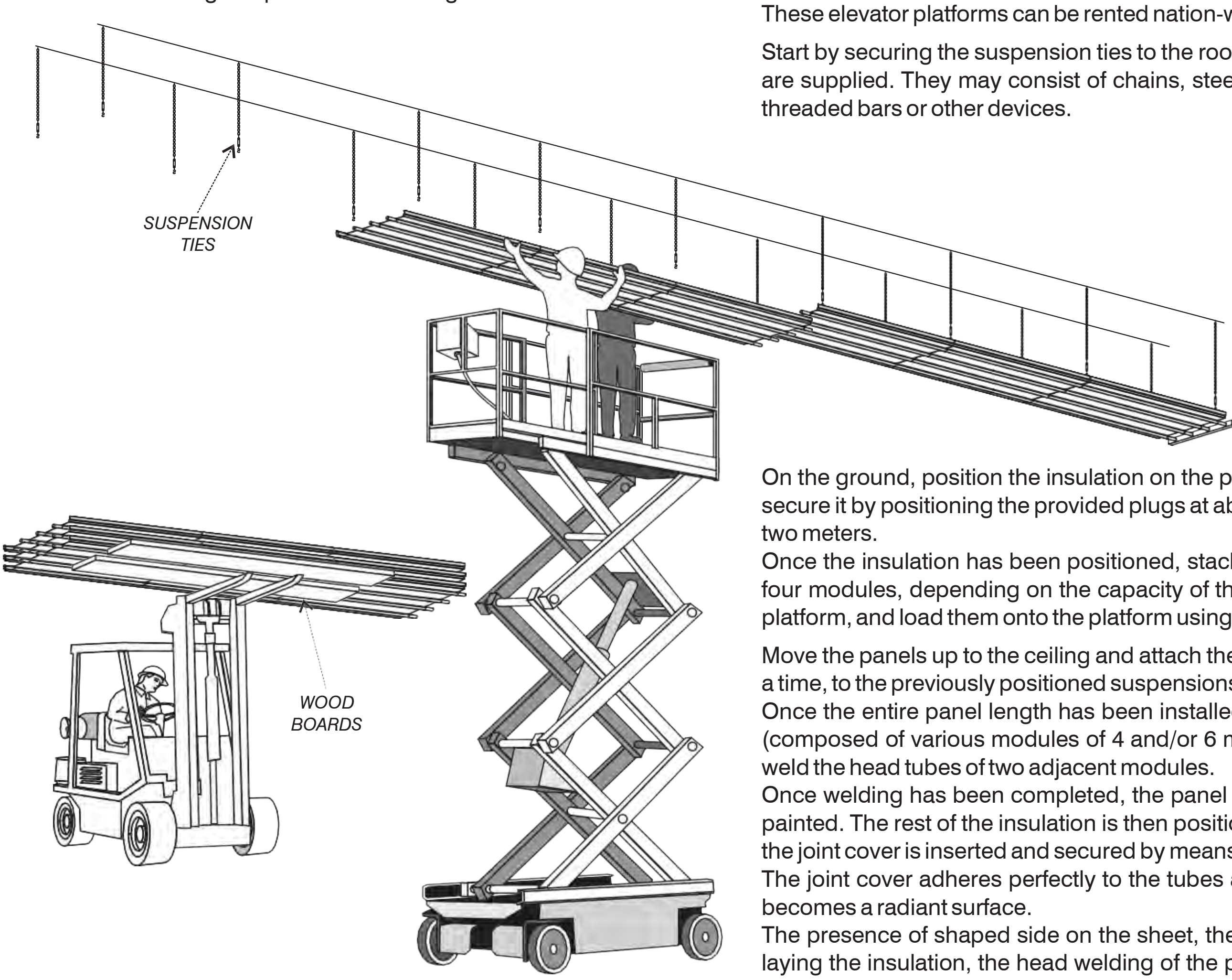
2.22 Assembly

If the panels are to be ceiling mounted in buildings with a height of over four meters, the safest and most economical way of doing this is to use elevator platforms with a lifting capacity of over 400 kg which are able to reach the highest parts of the building.



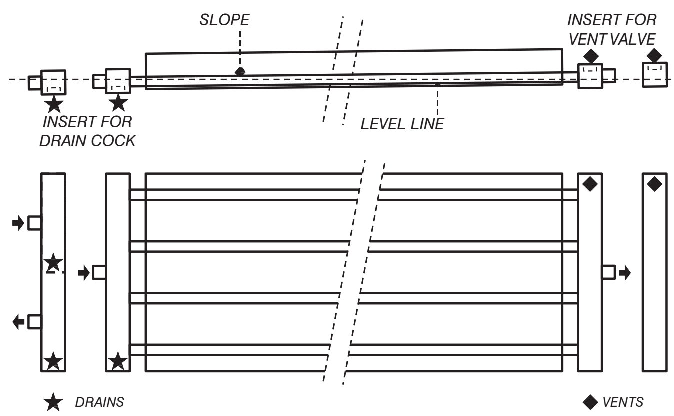
These elevator platforms can be rented nation-wide.

Start by securing the suspension ties to the roof. Tie rods are supplied. They may consist of chains, steel cables, threaded bars or other devices.

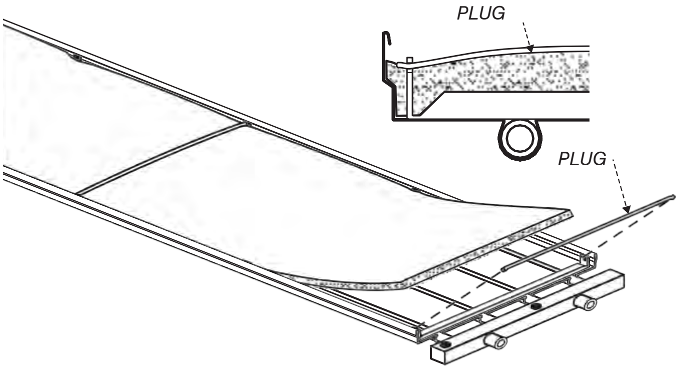


On the ground, position the insulation on the panels and secure it by positioning the provided plugs at about every two meters.
Once the insulation has been positioned, stack three or four modules, depending on the capacity of the elevator platform, and load them onto the platform using a forklift.

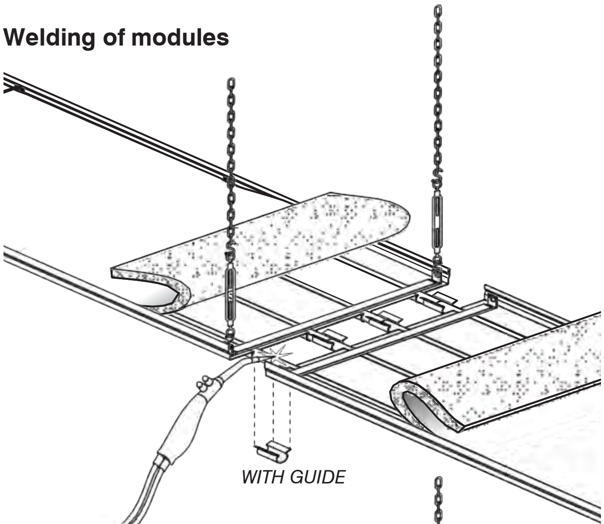
Move the panels up to the ceiling and attach them, one at a time, to the previously positioned suspensions.
Once the entire panel length has been installed (composed of various modules of 4 and/or 6 meters), weld the head tubes of two adjacent modules.
Once welding has been completed, the panel can be painted. The rest of the insulation is then positioned, and the joint cover is inserted and secured by means of clips.
The joint cover adheres perfectly to the tubes and it also becomes a radiant surface.
The presence of shaped side on the sheet, the ease of laying the insulation, the head welding of the perfectly aligned tubes, and the simplicity of inserting the joint cover all reduce and simplify assembly times and therefore installation costs.

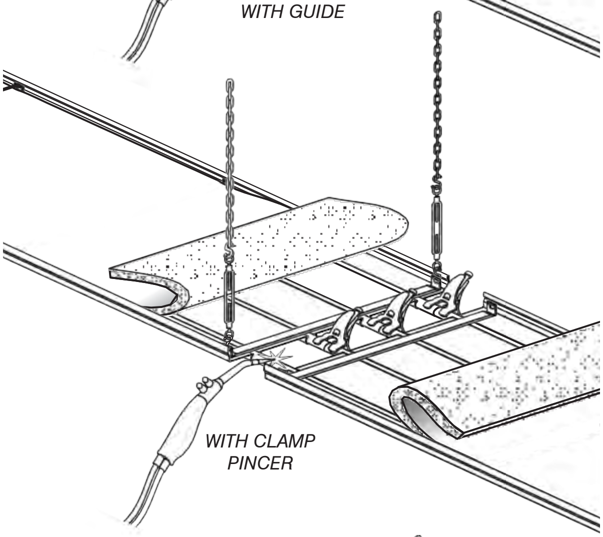


Laying and securing the insulating mat

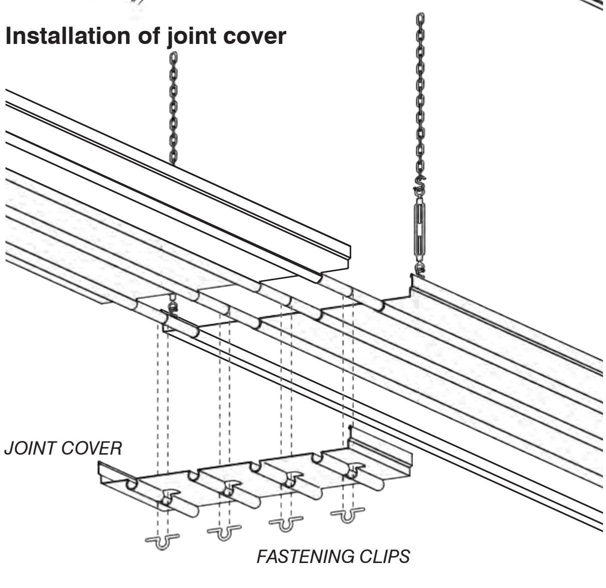


Welding of modules



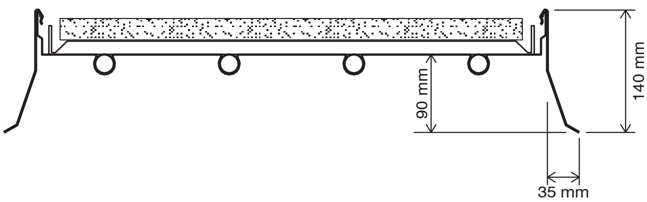


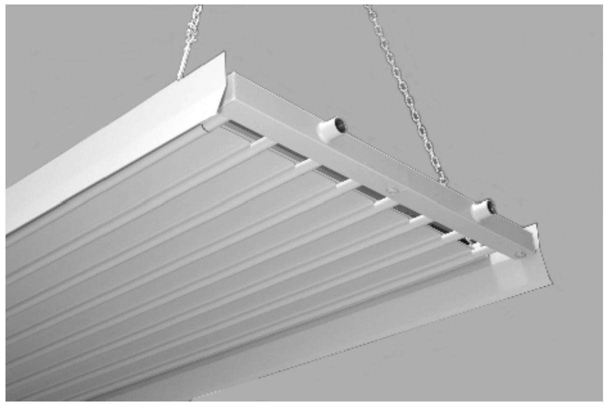
Installation of joint cover



3 ACCESSORIES

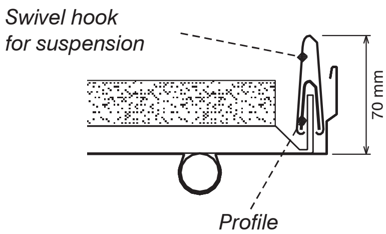
Anti-convections side skirts



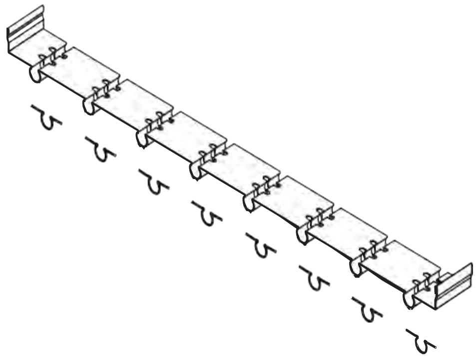


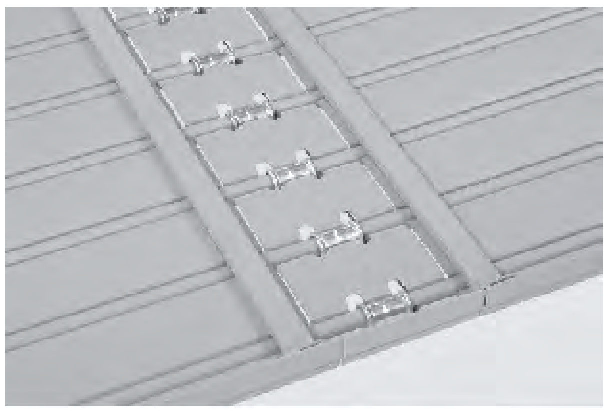
Concealed side profiles for suspensions at variable intervals

They allow suspension ties to be attached anywhere on the panel. These profiles, anchored directly on the brackets, stiffen the panel so that the space between one anchor and the next can be increased. They remain completely concealed.

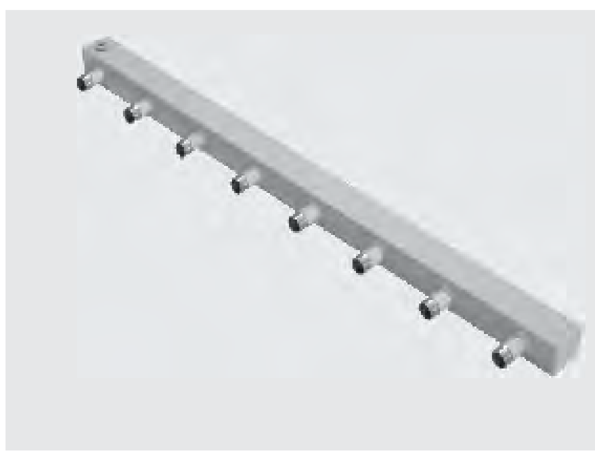


Joint covers for tube joints with sleeves for press-fitting

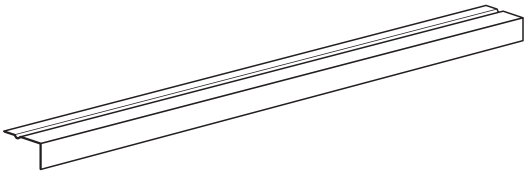


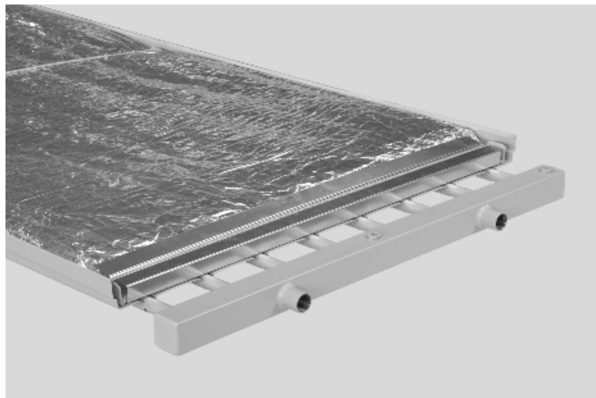


Headers for assembly with press-fitting

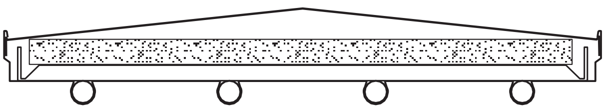


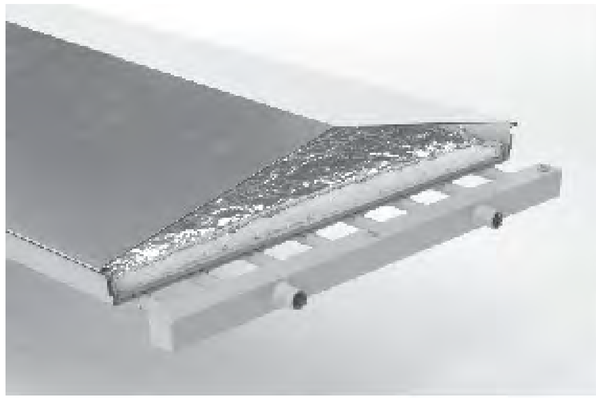
Insulation covers for heads of panels



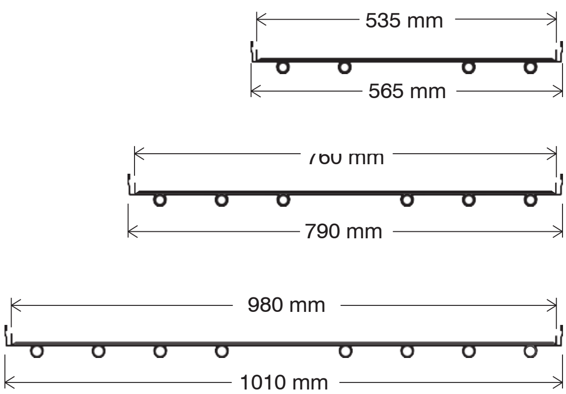


Upper sheet metal protections for gymnasiums





Panels with tube of ½", distance 111 mm with space for lamps



4 CERTIFICATIONS

4.1 EnergoAqua Eco radiant panels

Model	Number of test report as per European standard EN 14037-1,-2,-3	Nominal thermal emission $\Delta T = 55$ K F (*) W/m	Characteristic equation exponent n (*)	Characteristic equation constant K (*) W/K^n
2/150 ½"	DC203D12.1821	**180**	1,1752	1,6220
3/150 ½"	DC203D12.1821 / 1824	**244**	1,1708	2,2415
4/150 ½"	DC203D12.1824	**309**	1,1663	2,8830
5/150 ½"	DC203D12.1824 / 1827	**370**	1,1670	3,4450
6/150 ½"	DC203D12.1824 / 1827	**431**	1,1677	4,0040
7/150 ½"	DC203D12.1824 / 1827	**492**	1,1684	4,5598
8/150 ½"	DC203D12.1827	**554**	1,1691	5,1127
2/150 ¾"	DC203D12.1820	**190**	1,1760	1,7056
4/150 ¾"	DC203D12.1823	**318**	1,1763	2,8516
6/150 ¾"	DC203D12.1823 / 1822	**449**	1,1773	4,0143
8/150 ¾"	DC203D12.1822	**581**	1,1783	5,1687
4/100 ½"	DC203D12.1819	**278**	1,1828	2,4278
5/100 ½"	DC203D12.1819 / DC204D12.1977	**347**	1,1806	3,0599
6/100 ½"	DC204D12.1977	**413**	1,1784	3,6753
7/100 ½"	DC204D12.1977 / 1950	**466**	1,1802	4,1120
8/100 ½"	DC204D12.1977 / 1950	**516**	1,1820	4,5234
9/100 ½"	DC204D12.1977 / 1950	**566**	1,1837	4,9290
10/100 ½"	DC204D12.1950	**616**	1,1855	5,3288
4/100 ¾"	DC204D12.1989	**279**	1,1843	2,4274
6/100 ¾"	DC204D12.1985	**415**	1,1793	3,6744
8/100 ¾"	DC204D12.1985 / 1949	**534**	1,1825	4,6691
10/100 ¾"	DC204D12.1949	**650**	1,1857	5,6154

(*) Nominal thermal emission as per EN 14037, based on tests carried out at the HLK laboratory at the University of Stuttgart.
This emission, relative to ΔT=55 K is obtained from the equation:

$$F = K \times \Delta T^n$$

in which

F = thermal emission

K = characteristic equation constant

ΔT = difference between the average temperature of the fluid and the ambient temperature

n = characteristic exponent equation

4.2 Insulating panel

Fiberglass wool treated with thermosetting resin, covered on the upper side with aluminium foil.

Its properties include:

- chemical inertia, immune to attack by parasites and rodents, does not decay or absorb humidity, resistant to even substantial temperature changes.

The completely inorganic nature of fiberglass wool ensures its long-lasting performance.

Fire reaction

Class A1 according to test procedures of the EN 13501-1 normative

Thickness	40 mm
Thermal conductivity at an average temperature of 40°C	0,048 W/mK
Density	14 kg/m³ ±10%
Thermal resistance	0,83 m² K/W

5 TECHNICAL SPECIFICATIONS

Panels with electro-welded tubes	Panels with tubes without welding

Certified ceiling mounted radiant panels with emission certified as per harmonized European standard EN 14037, composed of:

Plate in quality steel sheet metal, produced using mechanical stamp and profile process, so as to obtain deep grooves that wrap 2/3 of the outer surface of the tube therefore obtaining maximum downward radiation.

Wide range of models based on the number of tubes they are made up of, 7 models with a distance of 111 mm and 7 models with a distance of 150 mm, the entire range is available with tubes of ½” or of ¾”.

Length of 4 or 6 meters obtained by assembling sheets of 2 meters so as to prevent them from deforming and to contain sliding between tubes and metal sheets within limits of elasticity.

Electro-welded tubes	Tubes without welding
Electro-welded steel **tubes** with a thickness of 1.5 mm made from laminated strip, diameter ½” (*or ¾”*), electronically tested and certified at the steelworks, suitable for liquids at a temperature of up to 120°C and operating pressures of up to 6 bar.	Steel **tubes** without welding (UNI 8863)) with a diameter of ½” (*or ¾”*), suitable for liquids at a temperature of up to 180°C and operating pressures of up to 16 bar.

Suspension brackets located about one every meter to stiffen the structure, composed of rectangular tube that is especially flat so as to allow continuity and adherence of the insulation to the sheet metal, thus permitting the integrity of thermal insulation.

Side edges with special profile obtained from the plate, thus extending the radiant surface. These contain and conceal the insulating mat.

Head **headers** welded to tubes and tested in the factory for the required pressures.

Fiberglass wool **mat** with a thickness of 40 mm, density 14 kg/m^3, covered on the upper face with aluminium foil, fire reaction class A1 as per EN 13501-1 normative.

Joint covers to be positioned on joints between modules, with the same profile as the main metal sheet, to be inserted by pressure and fastened from underneath with clips.

Painting carried out after washing, degreasing, and phosphating by immersion in tub containing water-soluble enamel with non-toxic epoxy powder resins, followed by oven baking. The standard colour is RAL 9016 white; other RAL colours are available on request.

This paint resists up to 170°C in systems supplied with water and 140°C in steam systems. For use at higher temperatures, there are specific paints.

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ENERGOTECH

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