versatile group

zehnder

Zehnder Carboline

Technical document for heating and cooling ceiling modules

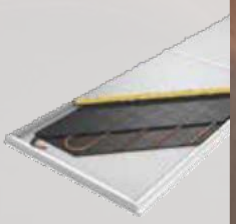
Responsive and energy efficient.

As regulations for the thermal protection of buildings become stricter, the insulation used in buildings has to keep improving. As the building fabric is so well insulated, temperatures inside rooms rise significantly during the warmer seasons of the year. This is because the high external temperatures are boosted by the interior heat load; this heat is created by computers, copiers, printers and other technical equipment – as well as the people occupying the space. As a result, the future is set to see significantly more interest in not only keeping buildings at a comfortable level of warmth, but also in creating rooms that are pleasantly cool.

Zehnder Carboline represents an elegant, innovative response to the demands placed on today's indoor climate control systems, by offering heating and cooling at an exceptionally high level of energy efficiency.

SPECIAL FEATURES OF ZEHNDER CARBOLINE

Due to expanded natural graphite, the Zehnder Carboline modules or heating and cooling ceiling elements provide optimal conditions for fast changes in temperature and energy-efficient usage once installed.



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MOUNTING AND INSTALLATION

Zehnder Carboline offers you numerous installation systems for closed ceilings and ceiling sails. Your specific requirements will be professionally accommodated by Zehnder's expert staff.

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TECHNICAL SPECIFICATIONS

- Calculation of pressure loss and minimum mass flow
- Heating and cooling performance
- Technical specification

PAGE **16 – 25**

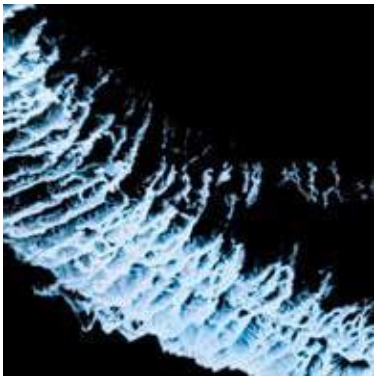
Special features of Zehnder Carboline

Due to the advanced design, excellent response characteristics are achieved in the event of a change of temperature. Combined with the excellent performance in the field of energy efficiency and architectural freedom, Zehnder Carboline modules for heating and cooling ceiling elements provide optimal solutions in all areas of application.

Natural graphite

What distinguishes Zehnder Carboline from other modules or heating and cooling ceiling elements? One aspect is the ideal properties of the material used for the heating and cooling ceiling elements: expanded natural graphite.
Combined with Zehnder's expertise in the development and manufacture of surface heating and cooling systems, the result is a high-performance system that can be easily and practically integrated into new and existing grid ceilings.
This makes Zehnder Carboline perfectly suited to providing indoor climate control in offices, schools, hospitals, meeting rooms and surgeries – in short, everywhere that a comfortable and healthy indoor climate plays a decisive role.

Natural graphite



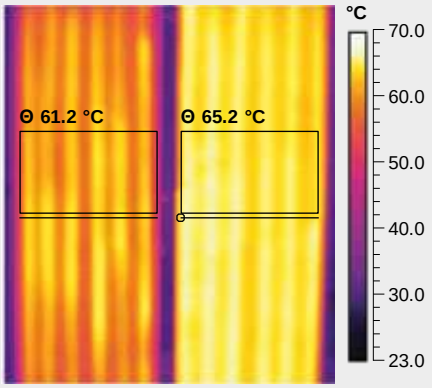
Expanded natural graphite

Expanded natural graphite: an innovative material with ideal properties

The material used for Zehnder Carboline is manufactured from scale-shaped natural graphite with a good crystalline structure.
It is a naturally occurring material and one of the inorganic modifications of carbon. The carbon atoms of the graphite are arranged in a hexagonal crystal lattice in flat, superimposed layers. The production process enlarges the volume of these parallel scales by 200 to 400 times. For Zehnder Carboline, the expanded natural graphite is then processed further into appropriately lightweight panels.

Areas of application

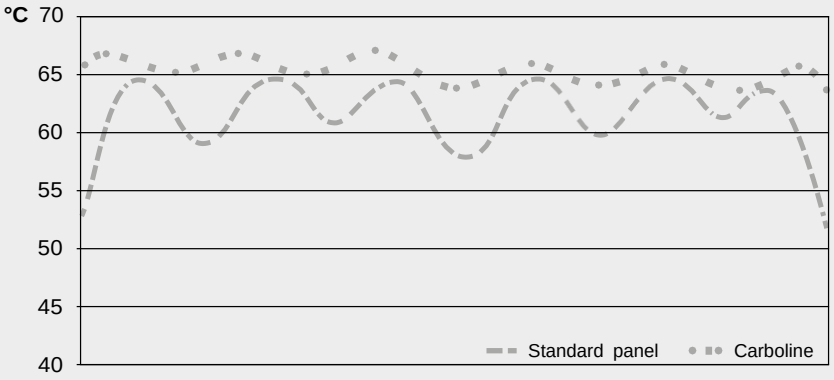
- Offices and meeting rooms
- Schools
- Nurseries
- Hospitals

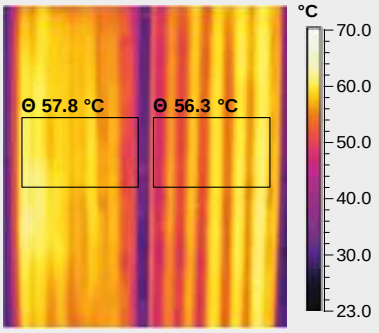


left: standard panel **right:** Carboline

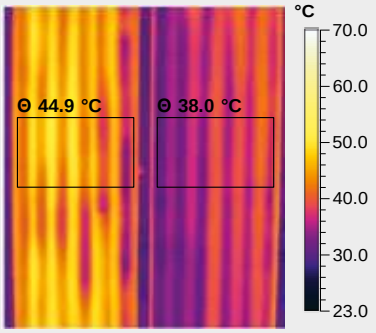
The thermography shows the comparison between Zehnder Carboline (panel on right) and a competing product, both exposed to the same temperature and mass flow.
Θ = average surface temperature

Temperature variance across the panel width

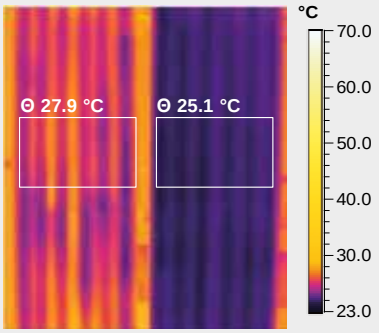




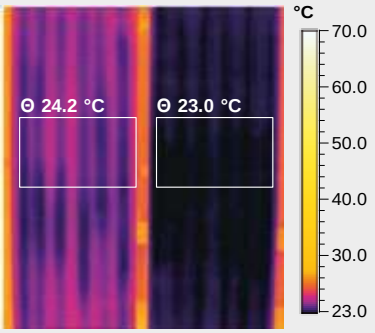
After 30 seconds
left: standard panel **right:** Carboline



After 1 minute



After 5 minutes



After 25 minutes

The reaction test also makes it clear that Zehnder Carboline reacts much more quickly than the competing product during a change of temperature from heating to cooling. Both systems were subjected to the same temperature and same mass flow for the test series. It can be seen that Zehnder Carboline cools much quicker and also shows better performance after 25 minutes.
Θ = average surface temperature

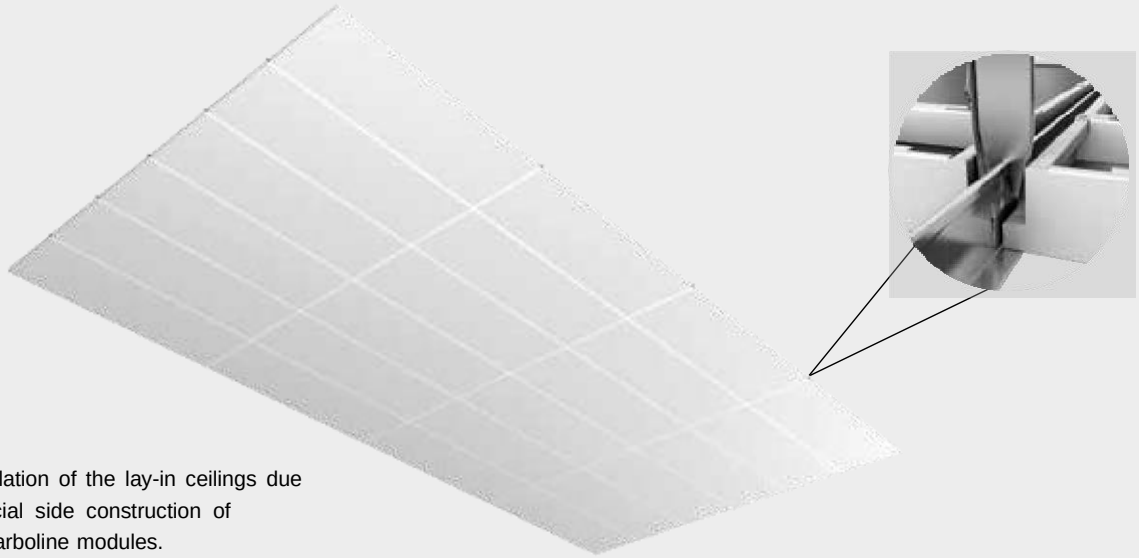
+ ADVANTAGE

- Good thermal conductivity
- Low density
- Non-flammable
- Long lifetime
- Physiologically inactive

Lay-in modules for closed ceilings

Zehnder Carboline is tailored for use in new or existing lay-in ceilings. The available basic grid dimension is 600 mm. The lay-in modules come in two standard widths and in five standard lengths. The length of the various lay-in modules is based on the basic grid dimension and can be up to five times the basic grid dimension.

The use of longer modules can reduce the cost of installation by up to 80% compared to conventional systems available on the market. The special side construction makes it possible to insert the modules easily into the lay-in ceilings.

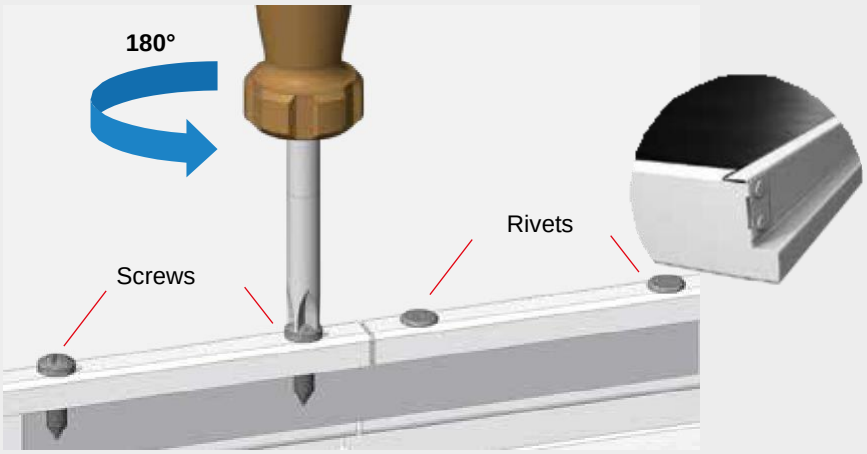


Easy installation of the lay-in ceilings due to the special side construction of Zehnder Carboline modules.

Anti-flec technology for lay-in modules

For use with lay-in modules in high temperatures and other applications.

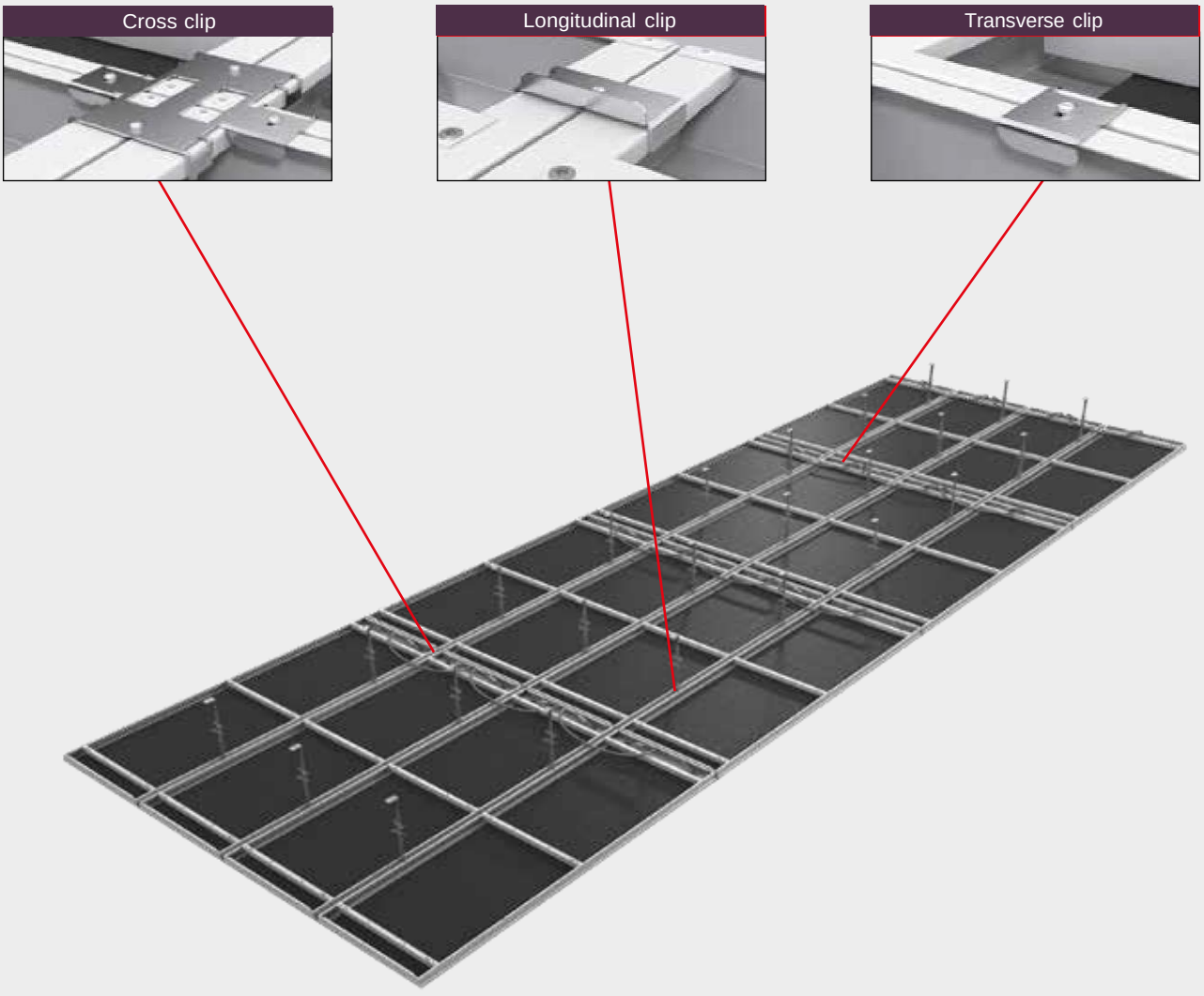
The Zehnder Carboline lay-in modules for grid ceilings are produced from a length of 1,500 mm with anti-flec technology. This ensures an even contact surface on the ceiling grid, even when heating. After laying the modules in the grid, the anti-flec profiles are loosened in the ceiling grid by opening the screw pairs.



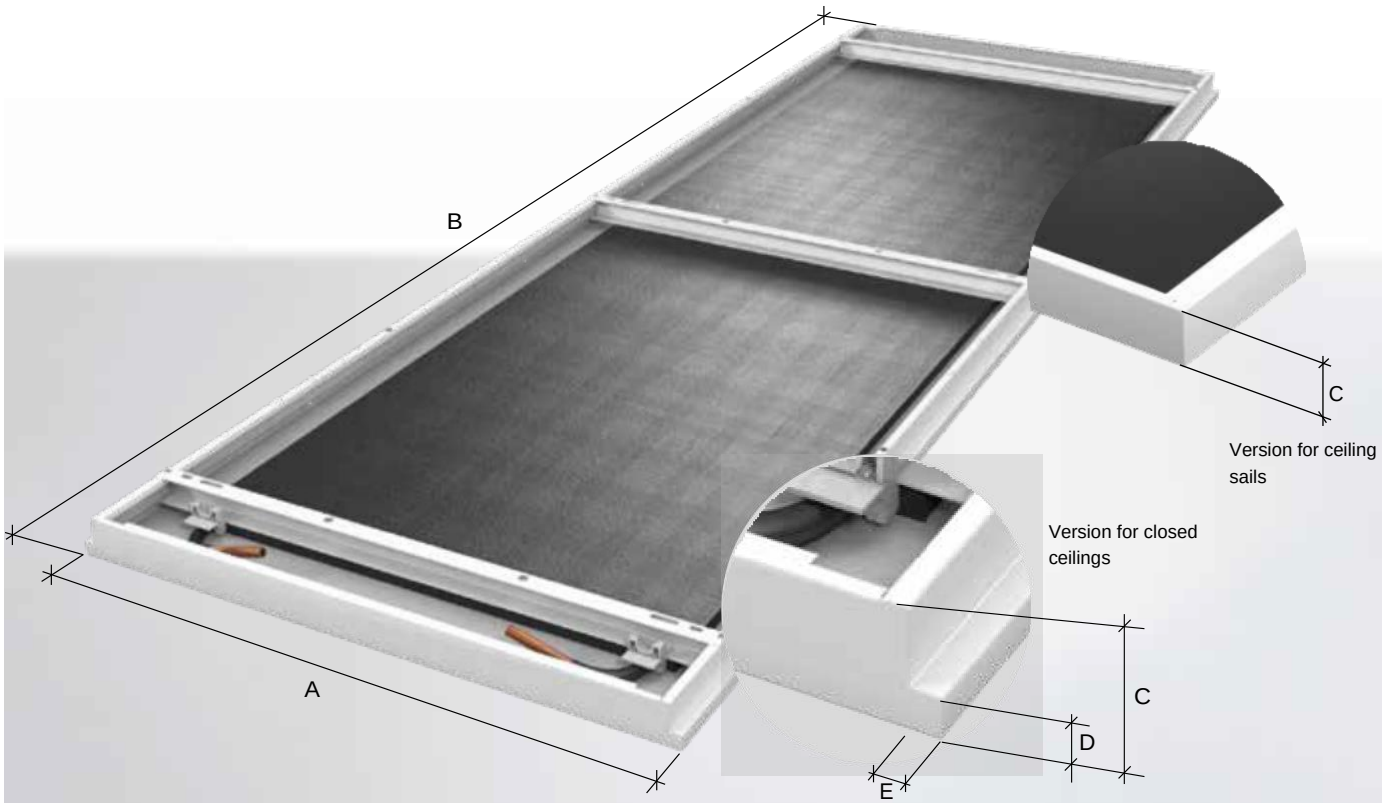
Freely suspended modules for ceiling sails

Efficient, flexible and great looks: Zehnder Carboline ceiling sails are the energy-efficient and cost-effective alternative for cooling and heating rooms in various types of building. As they only require a short space under the structural ceiling, they are even ideal for properties with low room heights. The dimensions of Zehnder Carboline ceiling sails can be tailored to suit the individual requirements of any design. Free-hanging and without a substructure, they are quick and easy to install. Additionally, they offer improved sound absorption compared with closed ceilings. With their unobtrusive design and broad colour palette, Zehnder Carboline ceiling sails are also easy on the eye.

Connecting clips for sail surfaces



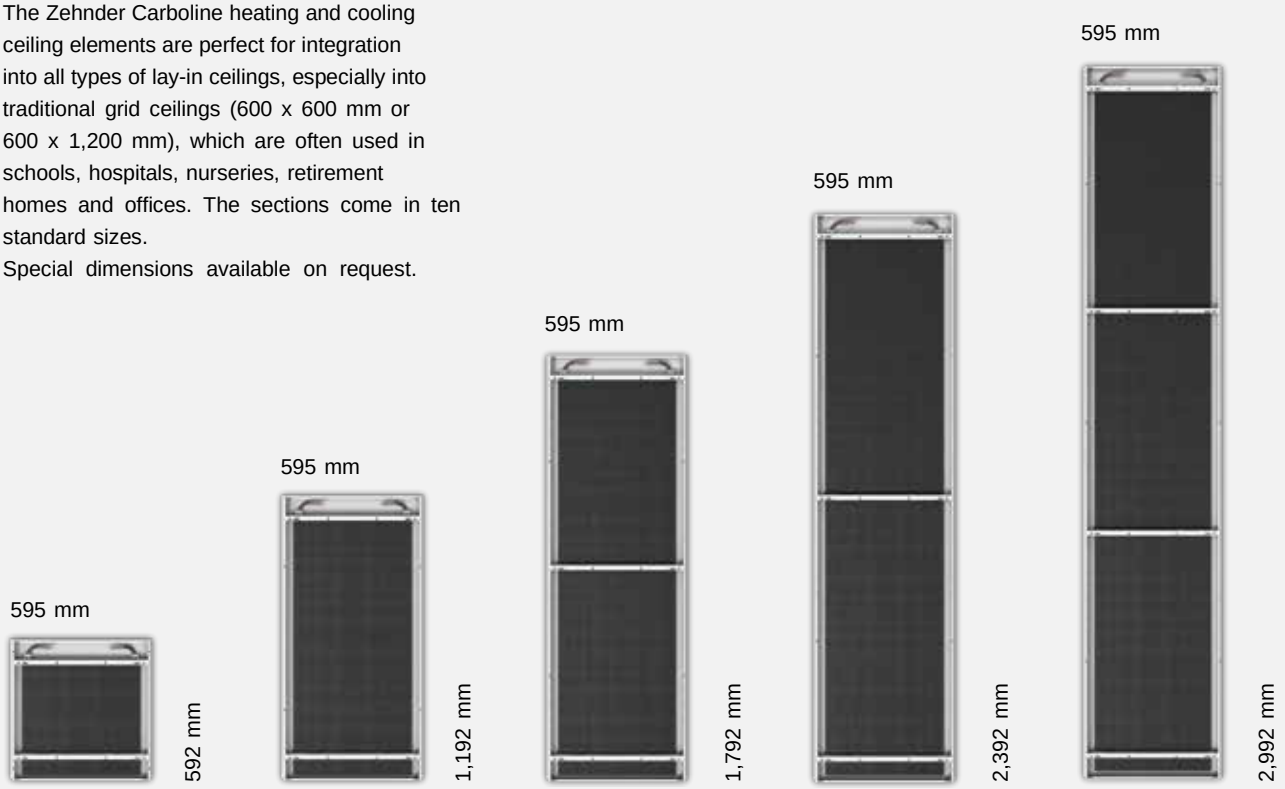
Flexible installation options



Module 600				
Dimension	**Description**	**Unit of measurement**	**Lay-in module**	**Ceiling sails**
A	Overall width	mm	595	600
B	Overall length	mm	592 - 2,992	600 - 3,000
C	Total height	mm	40	40
D	Height of the supporting edge	mm	14	-
E	Width of the supporting edge	mm	21	-

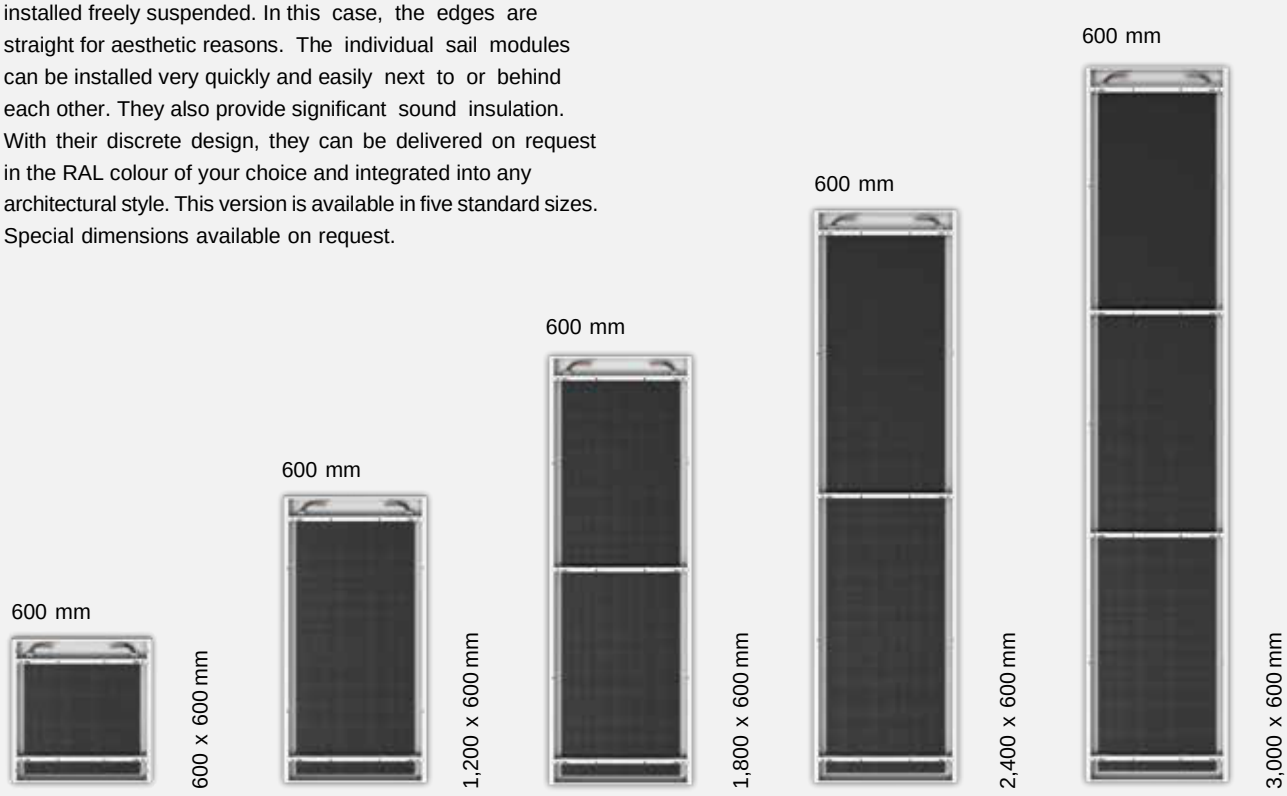
Modules for closed ceilings

The Zehnder Carboline heating and cooling ceiling elements are perfect for integration into all types of lay-in ceilings, especially into traditional grid ceilings (600 x 600 mm or 600 x 1,200 mm), which are often used in schools, hospitals, nurseries, retirement homes and offices. The sections come in ten standard sizes.
Special dimensions available on request.



Modules for ceiling sails

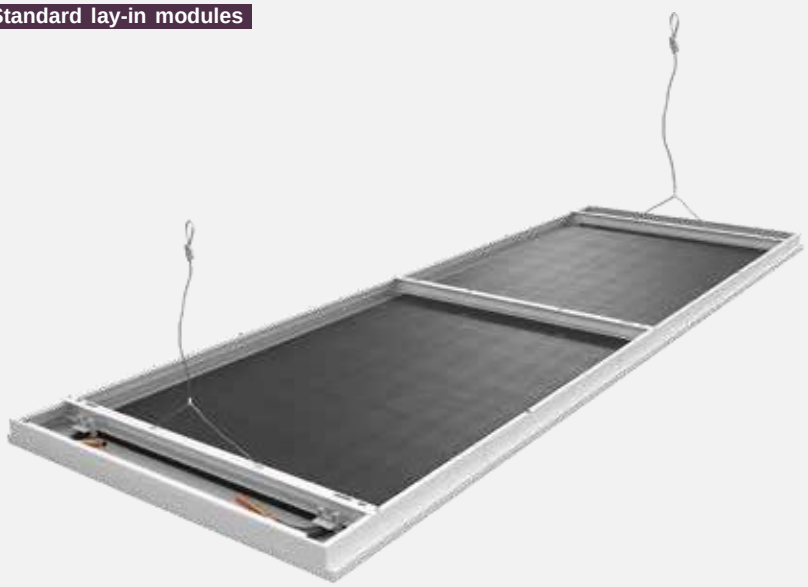
The Zehnder Carboline radiant ceiling panels can be installed freely suspended. In this case, the edges are straight for aesthetic reasons. The individual sail modules can be installed very quickly and easily next to or behind each other. They also provide significant sound insulation. With their discrete design, they can be delivered on request in the RAL colour of your choice and integrated into any architectural style. This version is available in five standard sizes.
Special dimensions available on request.



Suspension and attachment

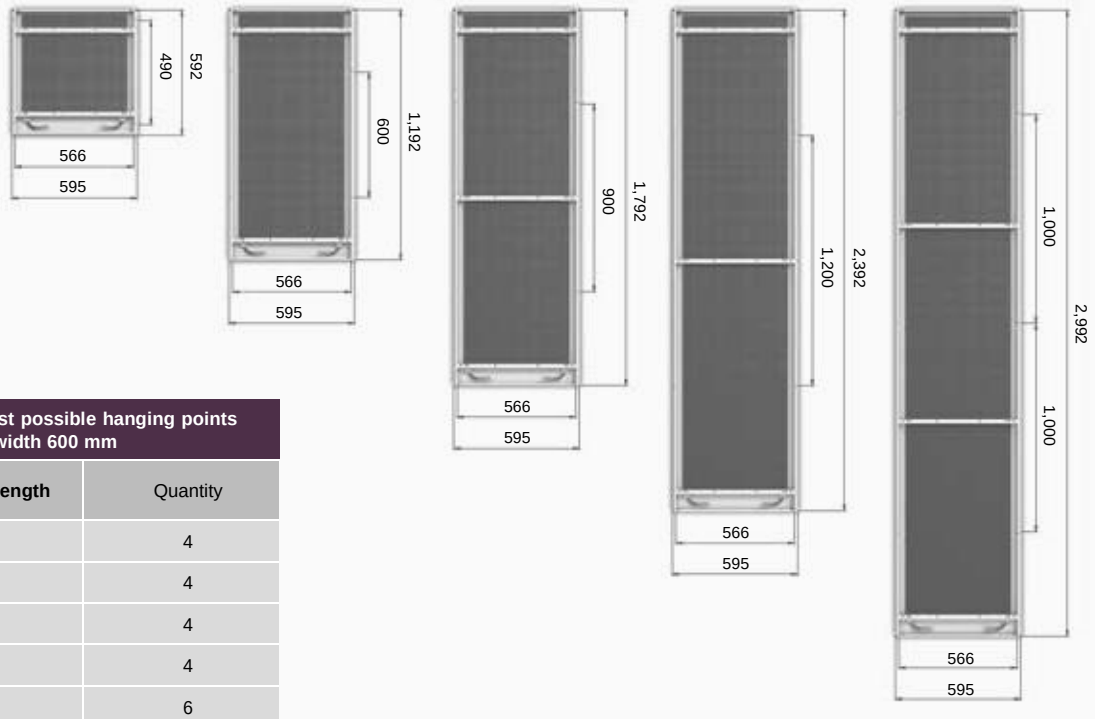
Our various installation kits for hanging and fastening the radiant ceiling panels have not only undergone rigorous safety engineering testing but will also integrate seamlessly into your overall ceiling layout.

Standard lay-in modules



Cross anchor

Zehnder Carboline's "grid version" is designed for installation in grid ceilings. We recommend the additional use of suspension wire to secure the panels to the ceiling.



Number of highest possible hanging points Nominal overall width 600 mm	
Nominal overall length	Quantity
600 mm	4
1,200 mm	4
1,800 mm	4
2,400 mm	4
3,000 mm	6

Suspension system using multi-clips (sails)

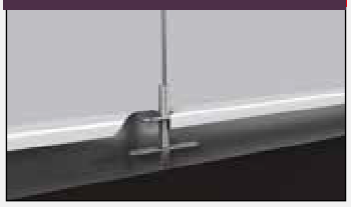
The multi-clip is pushed into the lateral edge of the module. The suspension points can therefore be varied.
*See the areas specified at the bottom of the drawings.

Multi-clip with carabiner

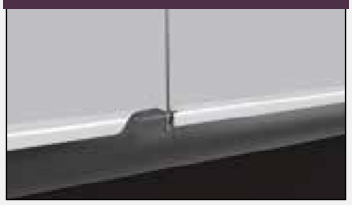
Multi-clip with wire cable and fine adjustment

Standard sail

Long hole with fine adjustment

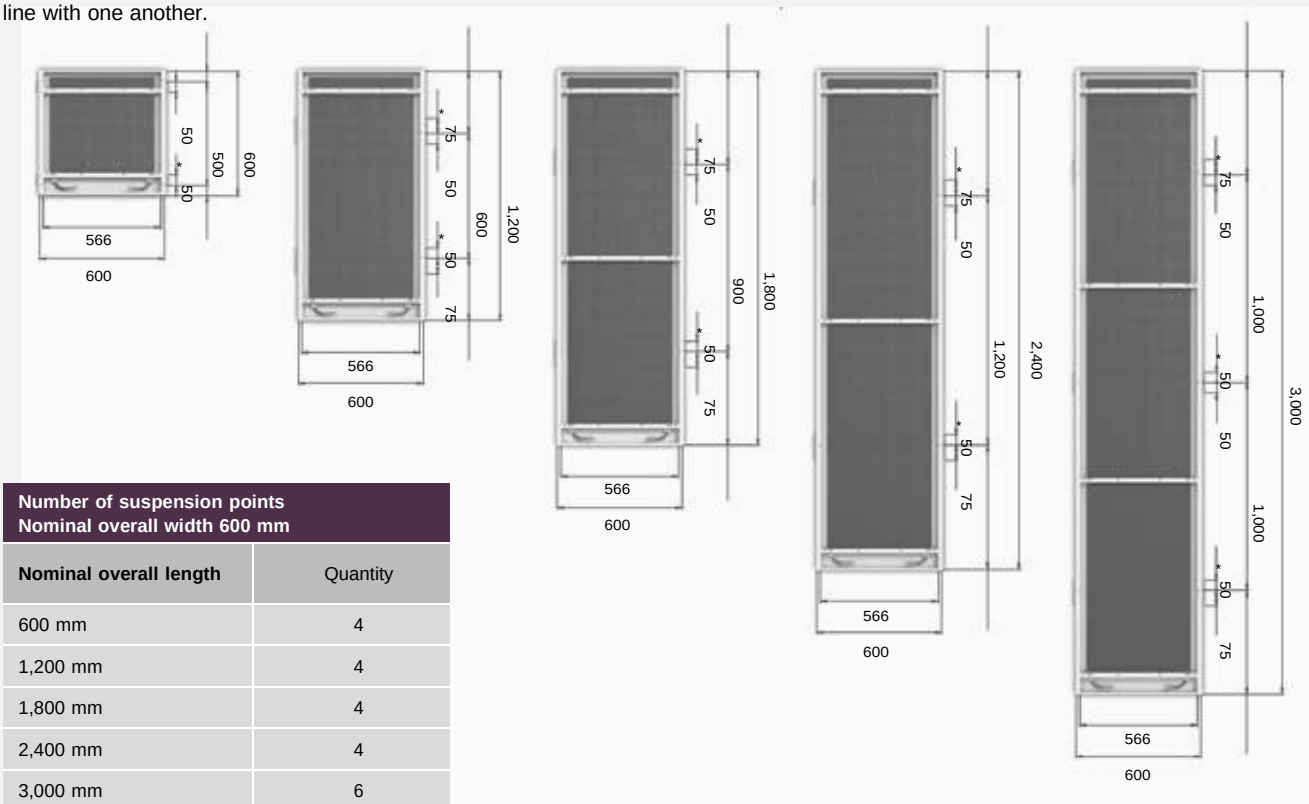


Cross anchor



Fine adjustments enable the modules to be aligned exactly, which makes installation easier.

The sail version can be attached directly to a concrete ceiling, for example. Sails of different sizes can be created by arranging the Zehnder Carboline panels in various combinations next to and in line with one another.

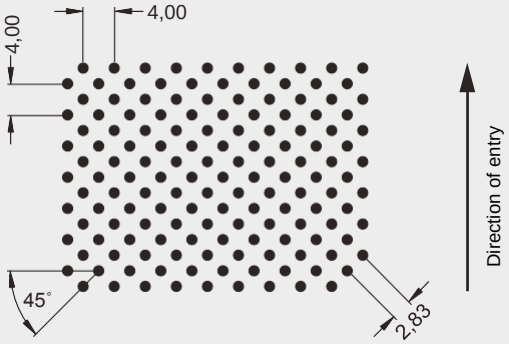


Number of suspension points Nominal overall width 600 mm	
Nominal overall length	Quantity
600 mm	4
1,200 mm	4
1,800 mm	4
2,400 mm	4
3,000 mm	6

Surface finishes

Zehnder Carboline offers the option of a smooth or perforated surface. The surface is coated with a high-quality powder coat finish. Zehnder radiant ceiling panels are available in the standard colour similar to RAL 9016. Additional colours and perforations available on request.

SOUND-ABSORBING VERSION, PERFORATED PLATE



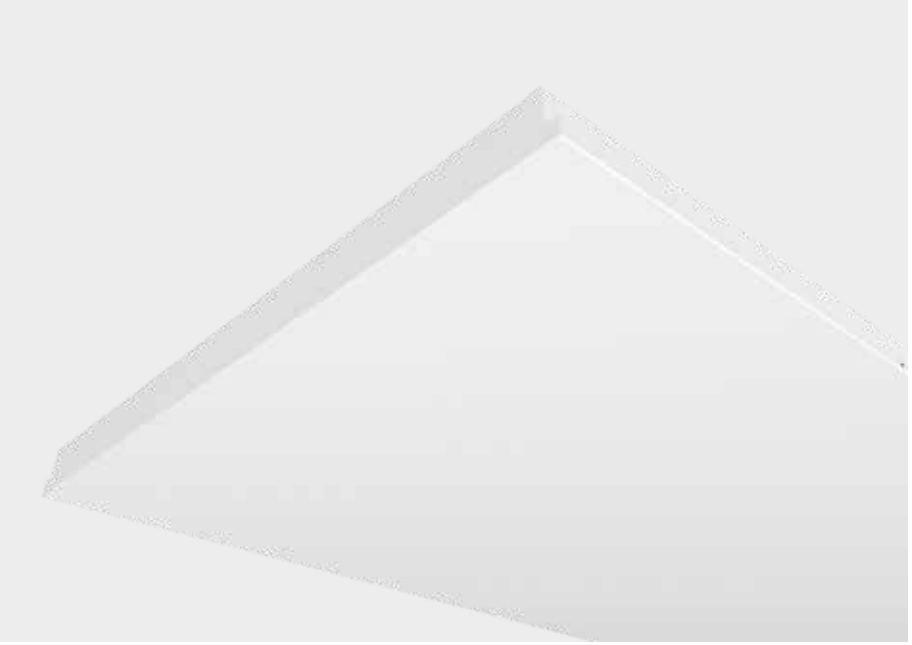
The Zehnder Carboline radiant ceiling panels can be perforated to provide optimised sound absorption. Sound waves pass through the perforations and are absorbed by the specially developed sound insulation. With sails, the sound waves are also absorbed by means of reverberation on the top of the product. This significantly reduces noise and the associated vibrations, especially in open-plan offices, call centres, schools, etc.
Acoustic calculation data on request.

Hole diameter	1.5 mm
Open cross section	22%

SURFACE FINISHES

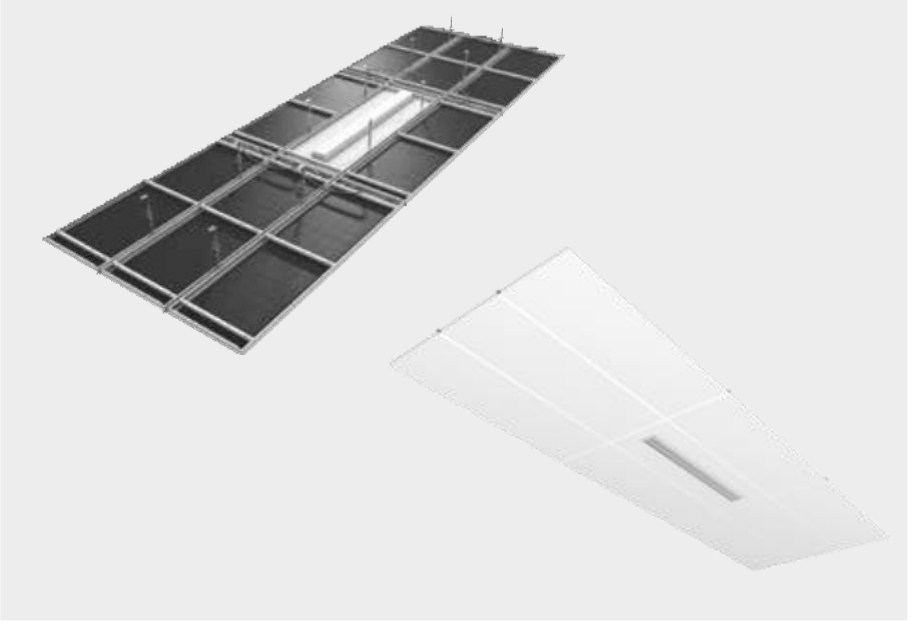
Standard colour
Smooth version, RAL 9016

More colours are available on request



SPECIAL SOLUTIONS

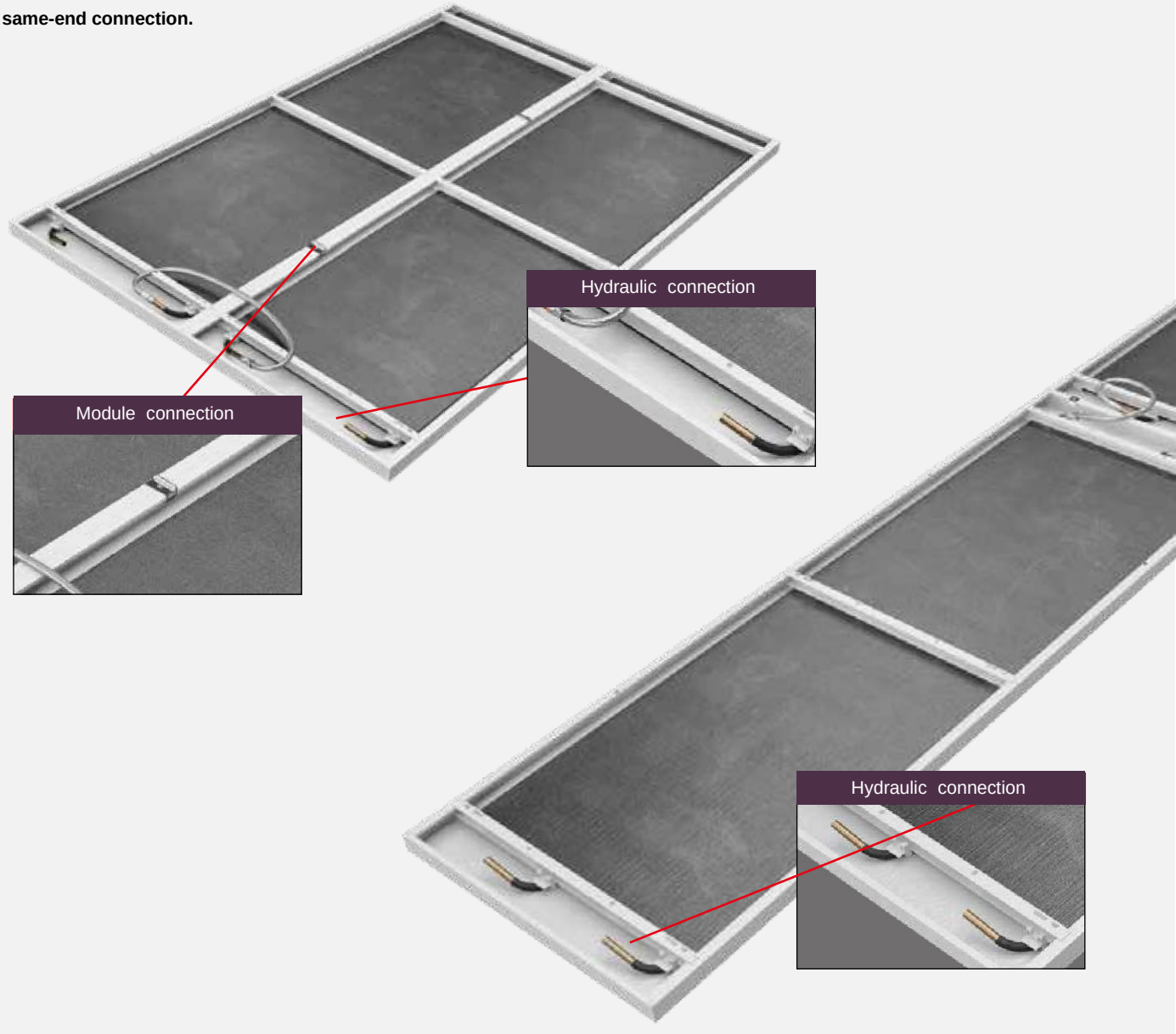
Ceiling cut-outs can be integrated into the panel elements of Zehnder Carboline as required. Especially in offices or meeting rooms, it may be necessary to provide ceiling recesses, e.g. for air outlets, projector brackets, speakers, fire alarms, lighting or similar. Zehnder produces the required ceiling cut-outs precisely to the customer's specifications.



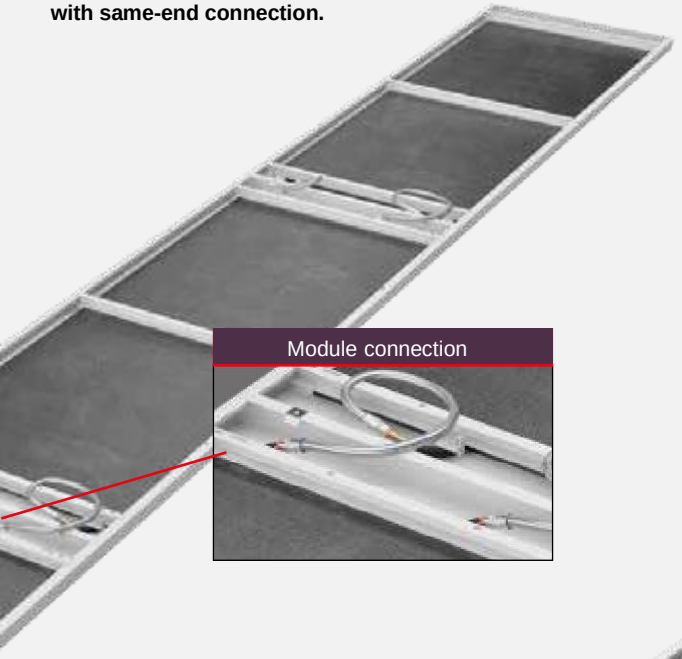
Connection technology
6-pipe rows

The Zehnder Carboline radiant ceiling panels can be installed as strips up to a maximum of 9 metres in length. In this case, the front-facing radiant ceiling panels have 2 serpentine circuits with hydraulic couplings on both sides of the panels, which enable a series connection.

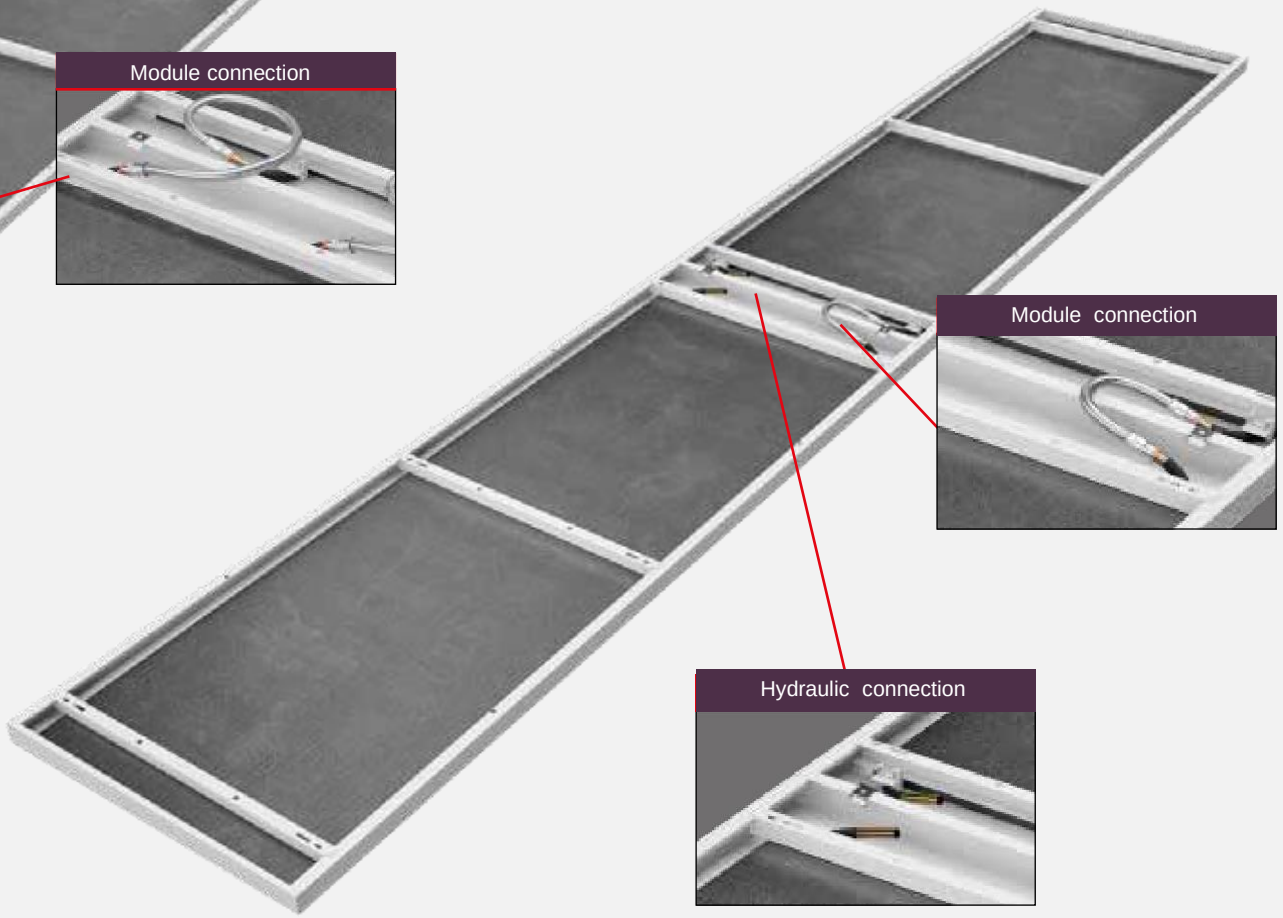
Two modules next to each other with same-end connection.



Three modules behind each other with same-end connection.

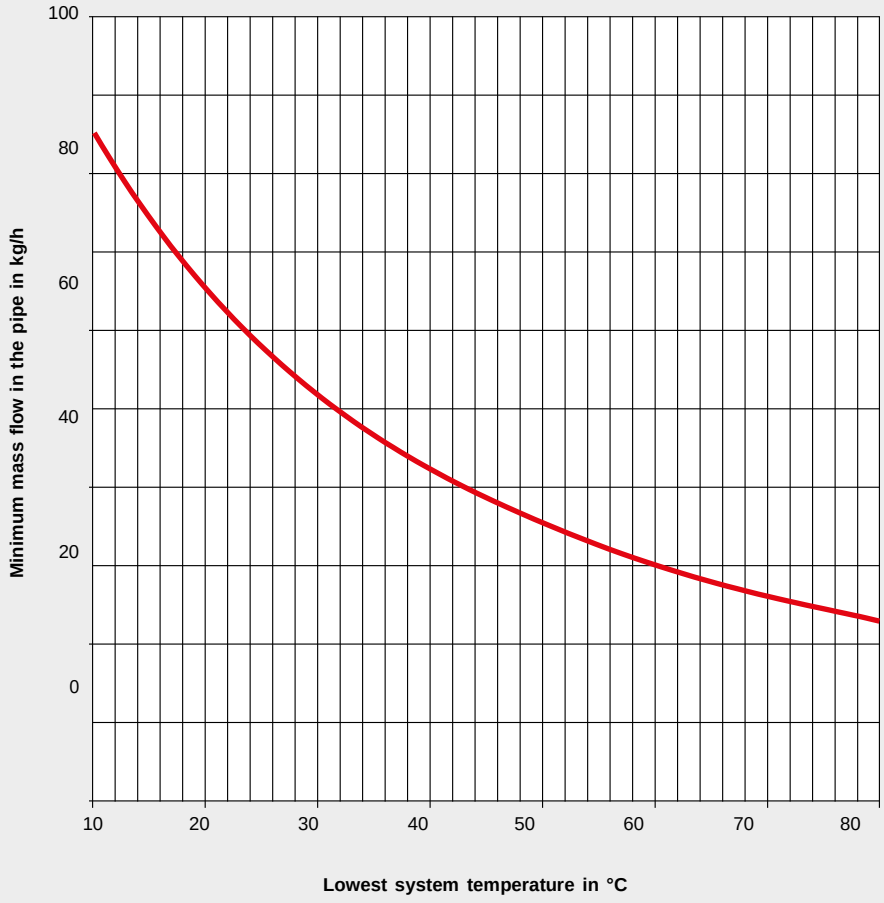


Two modules behind each other with centre connection.



Minimum mass flow

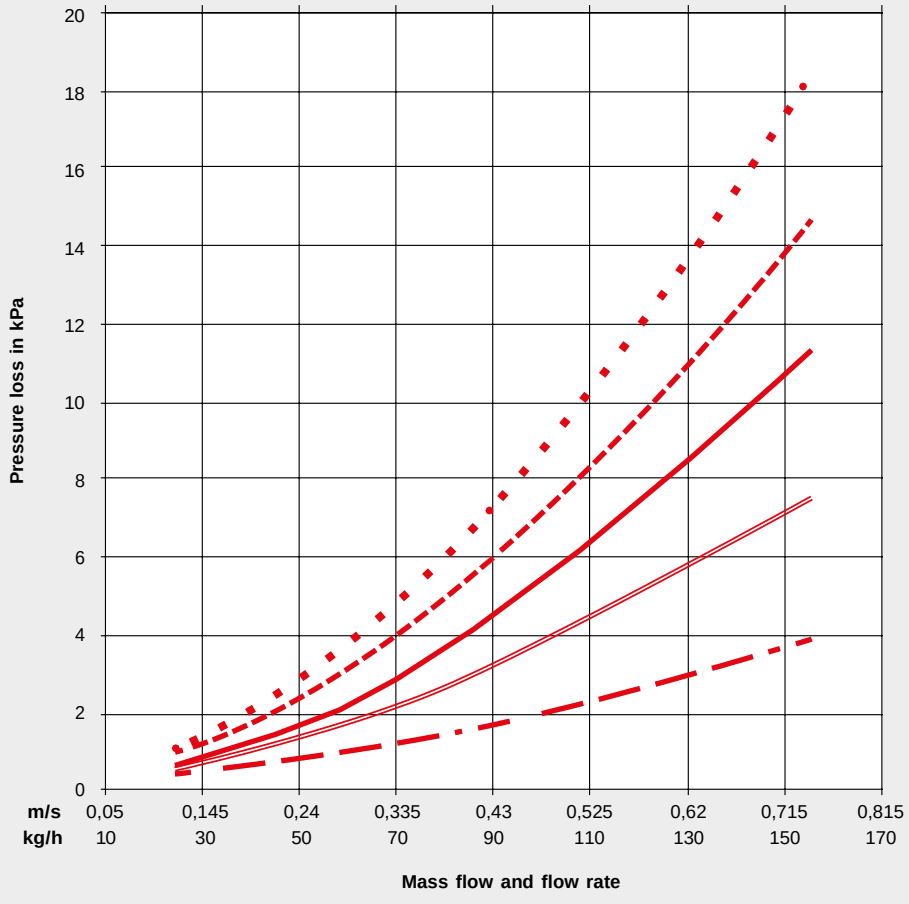
To maintain the output shown in the table, a turbulent flow must be ensured within the pipes in the radiant panel system. This minimum mass flow depends on the lowest system temperature. When heating, this corresponds to the return temperature. When cooling or in a combined cooling/heating mode, this corresponds to the cold water flow temperature. If the minimum mass flow per pipe is not achieved, this can result in a drop in performance of up to 15%.



Pressure loss calculation

The pressure loss, depending on the module size and mass flow, is shown in the diagram. The maximum permitted flow speed is 0.5 m/s.

Pressure loss per module



600 x 3000
600 x 2400
600 x 1800
600 x 1200
600 x 600

Heating and cooling performance

The following tables show the Zehnder Carboline heating and cooling performance dependent upon heating or cooling Delta T, measured based on EN 14037-3 (thermal output) and EN 14240 (cooling power).

Thermal outputs for 6-pipe activation

	Sail module / ceiling sail with insulation					Sail module / ceiling sail without insulation				
Dimensions	**600 x 600**	**600 x 1200**	**600 x 1800**	**600 x 2400**	**600 x 3000**	**600 x 600**	**600 x 1200**	**600 x 1800**	**600 x 2400**	**600 x 3000**
K	1,708	3,416	5,123	6,832	8,54	2,7391	5,4781	8,2172	10,956	13,695
n			1,180					1,194		
Δ t (K)	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**
70	257	514	771	1027	1284	437	874	1310	1747	2184
68	248	496	745	993	1241	422	844	1266	1688	2110
66	240	479	719	959	1198	407	814	1222	1629	2036
64	231	462	693	924	1155	392	785	1177	1570	1962
62	223	445	668	890	1113	378	756	1134	1512	1889
60	214	428	642	857	1071	363	727	1090	1454	1817
58	206	411	617	823	1029	349	698	1047	1396	1745
56	197	395	592	790	987	335	669	1004	1339	1673
55	**193**	**386**	**580**	**773**	**966**	**328**	**655**	**983**	**1310**	**1638**
54	189	378	567	756	946	320	641	961	1282	1602
52	181	362	543	723	904	306	613	919	1225	1532
50	173	345	518	691	863	292	585	877	1169	1462
48	165	329	494	658	823	278	557	835	1114	1392
46	157	313	470	626	783	265	529	794	1058	1323
44	149	297	446	594	743	251	502	753	1004	1255
42	141	281	422	562	703	237	475	712	950	1187
40	133	265	398	531	664	224	448	672	896	1120
38	125	250	375	500	625	211	421	632	843	1053
36	117	234	352	469	586	197	395	592	790	987
34	110	219	329	438	548	184	369	553	738	922
32	102	204	306	408	510	172	343	515	686	858
30	95	189	284	378	473	159	318	477	635	794
28	87	174	261	348	436	146	293	439	585	731
26	80	160	239	319	399	134	268	402	536	670
24	73	145	218	291	363	122	243	365	487	609
22	66	131	197	262	328	110	219	329	439	548
20	59	117	176	234	293	98	196	294	392	489
18	52	103	155	207	259	86	173	259	345	432
16	45	90	135	180	225	75	150	225	300	375
14	38	77	115	154	192	64	128	192	256	320
12	32	64	96	128	160	53	106	160	213	266
10	26	52	78	103	129	43	86	128	171	214

Note: the removal of the insulation has a positive effect on the cooling capacity (see table). However, this additional output can only be attributed to the room if it has an open ceiling.

Removing the insulation increases the heat output, but can lead to heat accumulation under the ceiling for larger room heights.

Cooling capacities for 6-pipe activation

	Sail module / ceiling sail with insulation					Sail module / ceiling sail without insulation				
Dimensions	**600 x 600**	**600 x 1200**	**600 x 1800**	**600 x 2400**	**600 x 3000**	**600 x 600**	**600 x 1200**	**600 x 1800**	**600 x 2400**	**600 x 3000**
K	3,0413	6,7879	10,5165	14,243	17,9726	3,6886	8,2328	12,7554	17,2753	21,7982
n			1,098					1,0916		
Δ t (K)	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**
15	59	133	206	279	352	71	158	245	332	419
14	55	123	191	258	326	66	147	227	308	389
13	51	113	176	238	300	61	135	210	284	358
12	47	104	161	218	275	56	124	192	260	328
11	42	94	146	198	250	51	113	175	237	299
10	38	85	132	178	225	46	102	158	213	269
9	34	76	117	159	201	41	91	140	190	240
8	**30**	**67**	**103**	**140**	**176**	**36**	**80**	**123**	**167**	**211**
7	26	57	89	121	152	31	69	107	145	182
6	22	49	75	102	129	26	58	90	122	154
5	18	40	62	83	105	21	48	74	100	126
4	14	31	48	65	82	17	37	58	78	99
3	10	23	35	48	60	12	27	42	57	72
2	7	15	23	30	38	8	18	27	37	46
1	3	7	11	14	18	4	8	13	17	22

Heating and cooling performance

The following tables show the Zehnder Carboline heating and cooling performance dependent upon heating or cooling Delta T, measured based on EN 14037-5 (thermal output) and EN 14240 (cooling power).

Thermal outputs for 6-pipe activation

	Lay-in module with insulation					Lay-in module without insulation				
Dimensions	**595 x 592**	**595 x 1192**	**595 x 1792**	**595 x 2392**	**595 x 2992**	**595 x 592**	**595 x 1192**	**595 x 1792**	**595 x 2392**	**595 x 2992**
K	1,7879	3,9904	6,1821	8,3731	10,5648	1,6847	3,7602	5,8255	7,89	9,9553
n			1,0819					1,1089		
Δ t (K)	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**
70	177	396	613	830	1047	187	418	648	877	1107
68	172	383	594	804	1015	181	405	627	849	1072
66	166	371	575	779	983	175	392	607	822	1037
64	161	359	556	753	951	170	379	586	794	1002
62	155	347	537	728	918	164	365	566	767	967
60	150	335	519	703	886	158	352	546	739	933
58	145	323	500	677	855	152	339	526	712	899
56	139	311	481	652	823	146	326	506	685	864
55	**137**	**305**	**472**	**639**	**807**	**143**	**320**	**496**	**671**	**847**
54	134	299	463	627	791	140	314	486	658	830
52	128	287	444	602	759	135	301	466	631	796
50	123	275	426	577	728	129	288	446	604	762
48	118	263	407	552	696	123	275	426	577	728
46	113	251	389	527	665	118	262	407	551	695
44	107	239	371	502	634	112	250	387	524	661
42	102	228	353	478	603	106	237	368	498	628
40	97	216	335	453	572	101	225	348	472	595
38	92	204	316	429	541	95	212	329	446	562
36	86	193	298	404	510	90	200	310	420	529
34	81	181	281	380	479	84	188	291	394	497
32	76	170	263	356	449	79	175	272	368	465
30	71	158	245	332	419	73	163	253	343	433
28	66	147	227	308	389	68	151	234	318	401
26	61	135	210	284	359	62	139	216	293	369
24	56	124	192	261	329	57	128	198	268	338
22	51	113	175	237	299	52	116	179	243	307
20	46	102	158	214	270	47	104	161	219	276
18	41	91	141	191	241	42	93	144	195	245
16	36	80	124	168	212	36	81	126	171	215
14	31	69	107	146	184	31	70	109	147	186
12	26	59	91	123	155	26	59	92	124	157
10	22	48	75	101	128	22	48	75	101	128

Note: the removal of the insulation has a positive effect on the cooling capacity (see table). However, this additional output can only be attributed to the room if it has an open ceiling.

Removing the insulation increases the heat output, but can lead to heat accumulation under the ceiling for larger room heights.

Cooling capacities for 6-pipe activation

	Lay-in module with insulation					Lay-in module without insulation				
Dimensions	**595 x 592**	**595 x 1192**	**595 x 1792**	**595 x 2392**	**595 x 2992**	**595 x 592**	**595 x 1192**	**595 x 1792**	**595 x 2392**	**595 x 2992**
K	2,5483	5,6877	8,8116	11,9346	15,0585	2,3729	5,2962	8,205	11,1129	14,0218
n			1,0921					1,14		
Δ t (K)	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**	**W**
15	49	109	170	230	290	52	116	180	244	307
14	45	102	157	213	269	48	107	166	225	284
13	42	94	145	196	248	44	99	153	207	261
12	38	86	133	180	227	40	90	139	189	238
11	35	78	121	164	207	37	81	126	171	216
10	32	70	109	148	186	33	73	113	153	194
9	28	63	97	132	166	29	65	100	136	172
8	**25**	**55**	**85**	**116**	**146**	**25**	**57**	**88**	**119**	**150**
7	21	48	74	100	126	22	49	75	102	129
6	18	40	62	84	107	18	41	63	86	108
5	15	33	51	69	87	15	33	51	70	88
4	12	26	40	54	68	12	26	40	54	68
3	8	19	29	40	50	8	19	29	39	49
2	5	12	19	25	32	5	12	18	24	31
1	3	6	9	12	15	2	5	8	11	14

Zehnder Carboline technical specifications

		Lay-in module					Sail module				
Dimensions	**Unit of measurement**										
Type width	-	600					600				
Type length	-	600	1,200	1,800	2,400	3,000	600	1,200	1,800	2,400	3,000
Actual width	mm	595					600				
Actual length	mm	592	1,192	1,792	2,392	2,992	600	1,200	1,800	2,400	3,000
Number of suspension points per module	piece(s)	4	4	4	4	6	4	4	4	4	6
No. of parallel pipes	piece(s)	6					6				
Pipe spacing	mm	90					90				
Pipe material / dimension (outside ø)	- / mm	copper pipe / 10					copper pipe / 10				
Panel material	-	Galvanised steel					Galvanised steel				
Parameters											
Max. operating temperature [1]	°C	83					83				
Max. operating pressure[2]	bar	6					6				
Weight											
Operating weight without water, with insulation	kg	4.56	8.15	12.04	15.62	19.51	4.56	8.15	12.04	15.62	19.51
Operating weight with water, with insulation[3]	kg	4.77	8.59	12.71	16.52	20.64	4.77	8.59	12.71	16.52	20.64

[1] A max. operating temperature of 50 °C only is possible with the perforated version.

[2] Higher operating pressure on request.

[3] Insulation made of mineral wool in LDPE foil, mass per unit area = 0.84 kg/m^2, λ = 0.03 - 0.04 W/(m*K)

Tender specification

Manufacture
The radiant panels shall be supplied by Zehnder UK, Watchmoor Point, Camberley, Surrey GU15 3AD. The panels are manufactured according to the TAIM e.V. quality standard, version: November 1998. The material will be galvanised sheet steel with a minimum thickness of 0.7 mm, with the lip on longitudinal side in line with static requirements.

The radiant panels will have a surface similar to RAL 9016, with the option of perforation, with hole pattern RD - L30 (diameter 1.5 mm - 22 % - 45 °), surrounding non-perforated edge, approx. 10 mm wide. A special heat-conducting acoustic fleece has been force-fitted to the back of the perforated version, without pleats, to improve sound absorption. Sound absorption measured according to EN ISO 345.

Design
The radiant panels will be 600 mm in width (595 mm for lay-in modules/grids), and lengths up to 3,000 mm (2,992 mm for lay-in modules/grids) in increments of 600 mm starting from 600 mm.

The radiant panels are suitable as lay-in modules/grids or as free-hanging ceiling sails.

Installation: Lay-in modules for T24 grid ceiling
The panels will lay flush, as lay-in metal cassettes for a visible T24 track supporting structure for heating and cooling, in a perforated or smooth version, for removing sensitive heat loads in an approximate ratio of 60 % via radiation and 40 % via convection.
A minimum suspension height of 350 mm (bottom edge of bare ceiling to upper edge of heating and cooling ceiling) is recommended.
Components and additional loads must be suspended from the bare ceiling separately; or with additional profiles and additional suspending brackets on the substructure. The supplementary work must be carried out professionally.

Installation: Free-hanging modules, sail version
The panels will be fixed to the bare ceiling via metal anchors approved by the building authorities. Anchors should be permitted to a load of at least 0.5 kN. Suspension height from bottom edge of reinforced concrete ceiling to bottom edge of metal cassette approx. 300 mm.

Hydraulic pipework for the individual metal cassettes as per the room-specific calculations.

Insulation
Heat and sound-absorbing insulating layer based on mineral wool, coated with black fleece on one side and shrink wrapped in LDPE foil as an option.

Pipe register
Factory-integrated copper pipe register fitted in a compressed graphite panel in an interlocking manner. This allows quick, even and excellent conductivity across the entire element. With flow and return connections. Pipe (10 mm) made of copper according to EN 12735-2. Deburred pipe ends are screwed to the cassette. Special axles and profiles used to provide strain relief and static reinforcement.

The cooling ceilings should be hydraulically connected so there is a max. pressure loss of 25 kPa per control circuit.

Performance
Thermal output according to EN 14037-3 with insulation for free-hanging panels, approx. 863 W @ ΔT 50 K and according to EN 14037-5 for lay-in modules /grid, approx. 728 W @ ΔT 50K based on testing of a 3,000 mm length panel with insulation. Cooling output certified to EN 14240, approx. 176 W @ ΔT 8 K for e.g. 600 mm x 3,000 mm with insulation free-hanging ceiling sails and 146 W @ ΔT 8 K for e.g. 595 mm x 2992 mm with insulation lay-in modules/grid applications.

Maximum operating temperature:	83 °C
Maximum operating pressure:	6 bar

Flexible Hoses
The Zehnder oxygen impermeable hose approved for heating systems, compliant to DIN 4726 consisting of temperature-resistant resilient butyl with a stainless steel braided sleeve.

The flexible hose connections with steel braiding will be 10 x 10 mm for panel inter-connections with brass push-fit connectors pressed on both sides. For connection to supply pipework they will be 10 mm brass push-fit connector on one side and 1/2" female thread for flat gasket on the other side. The connectors will be 750 mm, 1,000 mm, 1,500 mm or 2,500 mm in length. The connectors will work with a max. operating temperature of 80 °C and a max. operating pressure of 6 bar. A stainless steel corrugated version with a max. operating temperature of 83 °C is available on request.

Plastic connectors are not permitted. The copper pipes used on site to connect the flexible connection pipes must meet the requirements of EN 1057. Only copper pipes in the R220 (soft) and R250 (half hard) variant are permitted.

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