Heating and cooling ceiling systems
Radiant ceiling panels
Design example Zehnder ZIP

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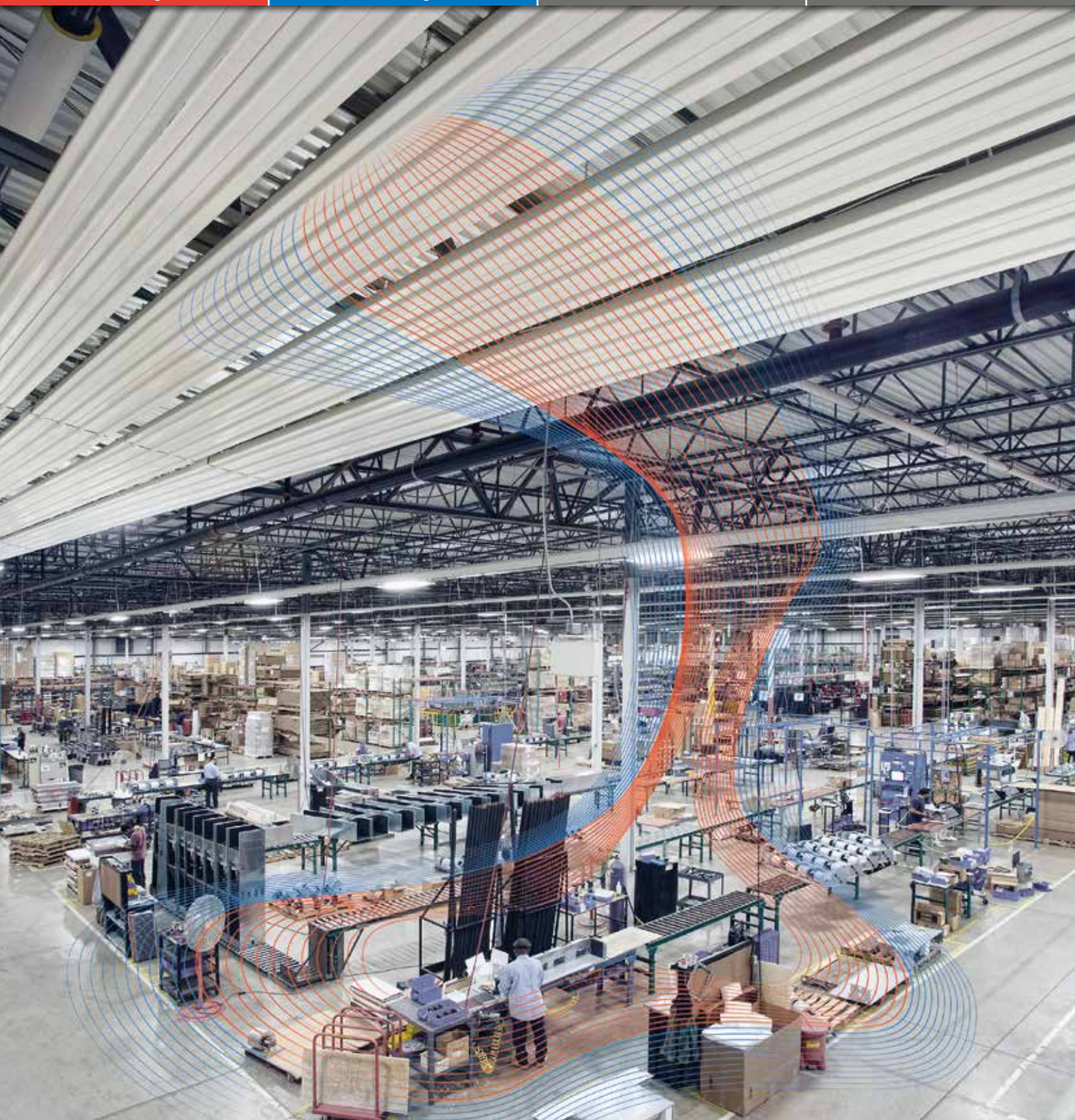


Design guidelines for Zehnder ZIP
Radiant ceiling panels

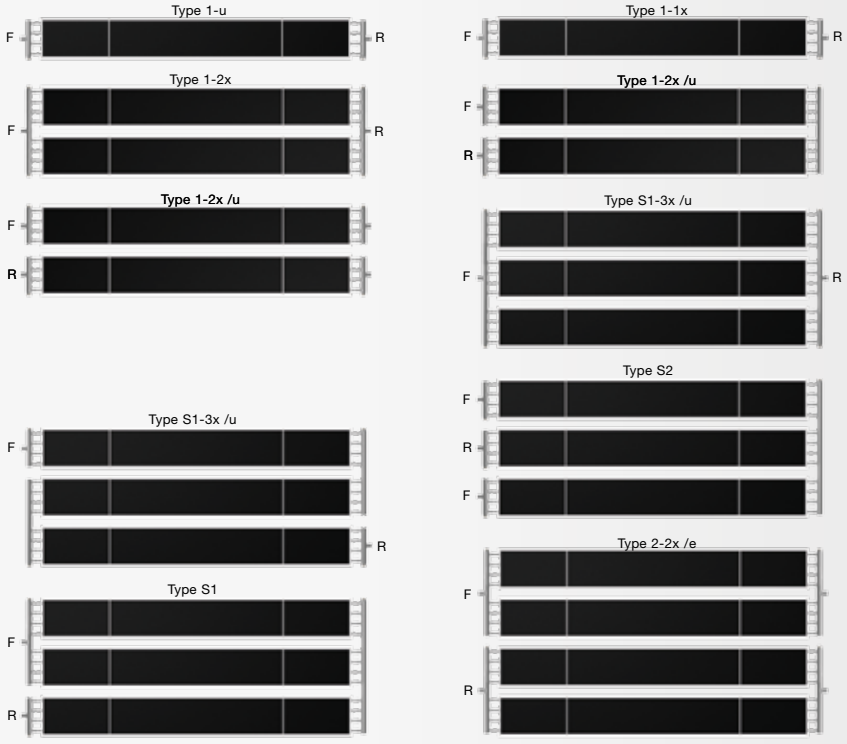
Required design data

1. Drawings including section views of all rooms.

2. Required outputs:
- Heating demand to be covered by radiant ceiling panels
- System temperatures: e.g. 90/70/16 °C

Zehnder ZIP model options

1. Available panel options:
a) Module widths: Single (1 ZIP): 320 mm, double (2 ZIP): 704 mm, triple (3 ZIP): 1088 mm, quadruple (4 ZIP): 1472 mm.
b) The length of radiant ceiling panels: up to 60 m (depending on hydraulic connections).
c) Partial length are available in 1m increments between 2 and 6 meters.
d) Connection possibilities:



2. Mounting options:
a) Standard mounting kits: concrete ceiling (KN53); sectional steel (KN54); trapezoidal sheet (KN56); angled steel carrier (KN57), horizontal steel carrier (KN58).
b) Special mounting kits: fixed or flexible swings, support tracks.

3. Insulation possibilities:
a) Glass wool insulation.
b) Insulation wrapped in LDPE foil.
c) High moisture version incl. styrodur and galvanized upper cover plates.

Panel positioning

1. Principles:
a) The panels are usually spaced in rows parallel to the outside walls.
b) Panels should ideally be as long as possible and identical (for ease of hydraulic balancing).
c) Turbulent flow should be maintained in the panels. This can be achieved by changes in length and hydraulic connections.
d) Minimum number of panel strips:

$$\frac{\text{Room width [m]}}{\text{Mounting height [m]}} + 1$$

e) Distance between the panels and the outside walls: 1/4 - 1/2 of panel mounting height.
f) Respect other built-in components (e.g. lighting, diffuser, smoke detectors).
g) Maximum velocity: 0.8 m/s

Calculation of the required number of radiant ceiling panels

1. Calculation of heating output:
   The design temperature difference ΔT is the difference between the average radiant ceiling temperature and the air temperature of the room.

$$\Delta t = \left| \frac{t_s + t_r}{2} - t_i \right|$$

Where:
t_s – supply temperature
t_r – return temperature
t_i – indoor temperature

2. Output of the panel [W/m] and collector pair [W] is given in the table below.

(for more values see Zehnder ZIP planning document)

	Single ZIP module		Double ZIP module		Triple ZIP module		Quadruple ZIP module	
K n	2.0871 1.1489	0.2456 1.3524	4.1742 1.1489	0.4912 1.3524	6.2613 1.1489	0.7368 1.3524	8.3484 1.1489	0.9824 1.3524
Δt (K)	W/m	W/collector pair	W/m	W/collector pair	W/m	W/collector pair	W/m	W/collector pair
80	321	92.0	641	184	962	276	1283	368
78	311	88.9	623	178	934	267	1246	356
76	302	85.9	605	172	907	258	1209	343
74	293	82.8	586	166	879	248	1173	331
72	284	79.8	568	160	852	239	1136	319
70	275	76.8	550	154	825	230	1100	307
68	266	73.9	532	148	798	222	1064	296
66	257	71.0	514	142	771	213	1028	284
64	248	68.1	496	136	744	204	992	272
62	239	65.2	478	130	718	196	957	261
60	230	62.4	461	125	691	187	922	249
58	222	59.6	443	119	665	179	886	238
56	213	56.8	426	114	638	170	851	227
55	**208**	**55.4**	**417**	**111**	**625**	**166**	**834**	**222**
54	204	54.1	408	108	612	162	816	216

3. Panel output [W/m] x length of the panel [m] + output collector pair [W] = total output panel [W]
4. Heat demand / panel output = number of panels.

Controls and balancing, limits

1. Controls:
   The ceiling panels can be controlled with constant regulators, on/off valves or mixing valves.

2. Balancing:
   For ease it is best to use reverse / return technology (Tichelmann system).
   To control zones a volume flow controller is advised.

Zehnder volume flow regulators:

Volume flow controller DN25	
Mass flow (kg/h)	Overall pressure loss (kPa)
150	20,1
210	22,5
270	24,7
330	26,7
390	28,6
450	30,4
510	32,0
570	33,4
630	34,8
690	36,0
750	37,2
810	38,3
870	39,3
930	40,2
990	41,1
1050	41,9

Volume flow controller DN32	
Mass flow (kg/h)	Overall pressure loss (kPa)
600	15,0
800	15,7
1000	16,3
1200	17,0
1400	17,7
1600	18,3
1800	19,0
2000	19,7
2200	20,3
2400	21,0
2600	21,7
2800	22,3
3000	23,0
3200	23,7
3400	24,3
3600	25,0

3. The total presssure loss of the system should not exceed 50 kPa.

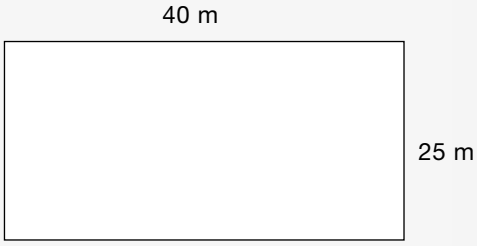
Available accessories and versions:

1. Volume flow regulation combinations (preset) DN25 und DN32.
2. Partial lengths are connected with crimp fittings, creating a series of longer radiant panels.
3. Connections are covered with cover plates.
4. Superimposed headers: the collectors are not visible from beneath.
5. Upper galvanized cover plates for dusty areas.
6. Ball guards for application in sports halls.
7. High moisture version with galvanized cover plates and styrodur insulation.

Design example of Zehnder ZIP radiant ceiling panels Heating

Boundary conditions and design steps

Room dimensions: **25 x 40 m**
Room height: **9 m**
Heating demand: **80 kW**
Heating installation parameters: **80 / 60 °C**; room temperature: **16 °C**



Installation height of ZIP ceiling panels (0.5 m below the ceiling): 9 m – 0.5 m = 8.5 m

Calculation of the distance of the radiant panels from the outside walls:
Between 8.5 m / 4 and 8.5 / 2 = 2.125 or 4.25 → 3.5 m were chosen.

Length of ZIP ceiling panels: 40 m – 2 x 3.5 m = 33 m

The minimum number of radiant ceiling panels: $\frac{25m}{8.5m} + 1 = \sim 4$ panels

Calculation of Δt:

$$\Delta t = \left| \frac{80°+60°}{2} - 16\,° \right| = 54\ K$$

ZIP panel ouput heating (see page 4):
204 W/m of a single radiant ceiling panel
54.1 W/collector pair

Calculation of required total length of single ZIP ceiling panels: 80000 W / 204 W/m = 392 m

Number of individual ZIP panels (later to be chosen: 1 ZIP, 2 ZIP, 3 ZIP or 4 ZIP):
392 m / 33 m per strip = 11.9 panel strips –> 12 x 1 ZIP; 6 x 2 ZIP; 4 x 3 ZIP; 3 x 4 ZIP of 33m.

Total output:
ZIP ceiling panel heating output: 12 x 33 m x 204 W/m = 80784 W
Collector pair output: 12 x 54.1 W = 649 W

Total output: 80784 W + 649 W = 81433 W

Mass flow: $\frac{81433\ W}{1.163\ Wh/kg/K \times (80°-60°)} = 3501\ kg/h$

(Chosen: 3 ZIP with S1 connection)

Design example of Zehnder ZIP radiant ceiling panels Heating

Calculation of pressure drop:

Flow: 3501 kg/h / 12 panel strips / 8 tubes per strip = 36.5 kg/h
Return: 3501 kg/h / 12 panel strips / 4 tubes per strip = 73 kg/h

Mass flow (supply): $\frac{3501\ \text{kg/h}}{12\ \text{modules x 4 tubes}} \times \frac{3\ \frac{\text{strips}}{\text{unit}}}{2\ \text{plates}} = 109\ \text{kg/h}$

Mass flow (return): $\frac{3501\ \text{kg/h}}{12\ \text{modules x 4 tubes}} \times 3\ \frac{\text{stripes}}{\text{unit}} = 219\ \text{kg/h}$

Pressure loss per pipe according to Zehnder ZIP planning document:
a) Supply panels: 70 Pa/m
b) Return panels: 270 Pa/m

Mass flow collector pair: 4 x 219 kg/h = 876 kg/h

Pressure loss header pair according to Zehnder ZIP planning document: 1200 Pa

Total pressure loss collector pairs: 1200 Pa / 2 x 3 = 1800 Pa

The total pressure loss panels and collectors/headers:

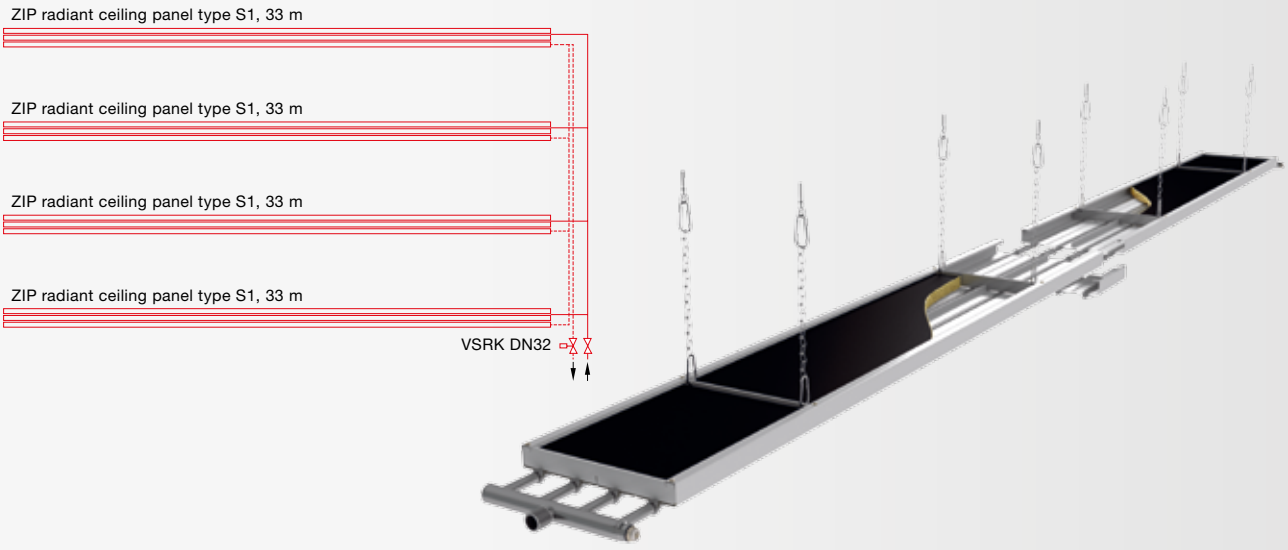
$\Delta p = 270\ \frac{\text{Pa}}{\text{m}} \cdot 33\text{m} + 70\ \frac{\text{Pa}}{\text{m}} \cdot 33\text{m} + 1800\ \text{Pa} = 13000\ \text{Pa}$

Dimensioning of the volume flow regulator:

The selected design allows for a Tichelmann layout; one flow regulator can be used for the entire system:
Total mass flow: 3501 kg/h

The selection of flow regulator is done according to the table in chapter “Controls and balancing, limits”.
For the given design DN32 is chosen, resulting in an additional pressure loss of 25.0 kPa.

ZIP ceiling panel layout:



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