RHC-PLAN-BR1, V03/08, English, subject to alterations

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Zehnder ZBN
Ceiling Heating and Cooling System
Technical catalogue

Comfortable, energy efficient, versatile: Zehnder ZBN Ceiling Heating and Cooling Systems.

Traditionally, a choice has to be made whether to use a conventional heating system or air conditioning to achieve the desired internal conditions in a building. As energy costs increase the expectation for high comfort levels is also increasing. The challenge is to provide an energy efficient yet comfortable system: Zehnder ZBN offers the solution.

Zehnder has been producing radiant ceiling systems for more than 50 years, and is now established as Europe‘s largest manufacturer of these products. With thousands of satisfied customers in Europe, Asia and the USA, the quality of the Zehnder systems is now globally recognized.

Zehnder ZBN radiant ceiling panels can provide heating and cooling both comfortably and efficiently. They can be used in all rooms up to 30 m height, for example, in:

- Shipyards and maintenance hangars
- Factories
- Goods depots and high-rise warehouses
- Exhibition areas and showrooms
- Schools and hospitals
- Sports and multi-purpose halls and many others

Energy savings of more than 40 % are possible in comparison to other systems.

Zehnder ZBN radiant ceiling panels are available in a variety of widths and lengths and can be specified to suit each application. Features such as lighting apertures, mitred corners and perforations for acoustic performance can be easily incorporated.

We would welcome the opportunity to discuss any future projects with you.

Front page: Testing hall, Airbus A380, IABG Dresden (D) (Photo copyright IABG)

Film studios Babelsberg (D)

General

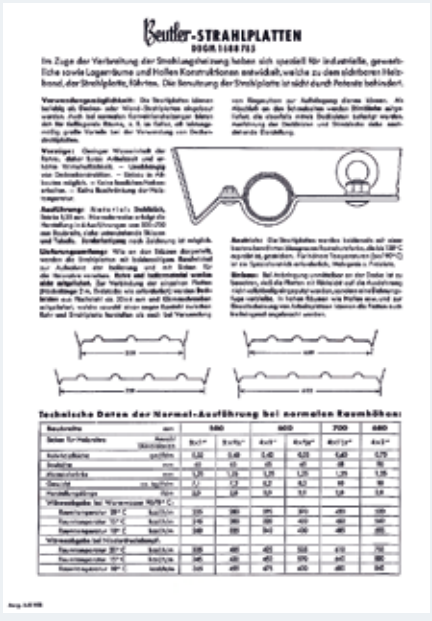
Product Description

Technical Data

Experienced in radiant ceiling systems since 1952

Zehnder has been producing radiant ceilings systems for more than 50 years, originally as Beutler (see below) and is now established as Europe´s largest manufacturer of these products.

This wealth of experience and knowledge make Zehnder the ideal partner for all heating and cooling solutions.



Historical radiant panel product brochure

Arminius market hall, Berlin (D)

Indoorsports stadium Berlin (D)

How does our system work?

In order to understand how Zehnder ZBN radiant ceiling panels work, it is useful to review the various forms of heat transmission.

Heat conduction
Heat energy is tranferred through an object, or objects in direct contact, by vibration of the molecules next to each other. Example: Touching a hot object.

Convection
When a liquid or gas is heated, hot areas of the medium flow and mix with the cool areas. Example: Hot air rising from a convection heater.

Radiation
A warm or hot object gives off infrared electromagnetic radiation, which can be absorbed in another, cooler, object thus heating it up. The amount of heat emitted or absorbed depends on the nature of the surfaces and the temperature difference.
Example: Feeling the radiant heat of the sun on a snow-covered mountain.

The Heating operation of our system
Zehnder ZBN radiant ceiling panels emit a large proportion of their heat by radiation. The remaining heat is transmitted through convection.

The emission of the radiation is achieved by having heated water flow through the tubes. The entire system emits this heat into the room.

The advantage of our system is in the direct action of heat on the body without having to heat the air.

The temperature we experience is a combination of radiant and air temperature. Cooler air temperatures can be offset by increasing the radiant component to achieve comfortable resultant temperatures.

By using radiant panels to increase the surface temperatures of the room, the air temperature is normally reduced by 3 K and still achieves comfortable internal temperature conditions. This is the most energy efficient method of heating.

The Cooling operation of our system
The cooling action works on the same physical principles as the heating action, although now the heat is not emitted, but absorbed:

The cold radiant ceiling panel absorbs radiant heat from the hotter surfaces. This constitutes approximately 60 % of the cooling effect. The remaining 40 % is achieved by convection: The warm room air, which is less dense, rises and flows along the ceiling. It then transfers its heat energy by convection to the cooler radiant ceiling panel. The cooled air which is now denser falls back into the room.

The perceived temperature in the room is actually lower than the air temperature due to the radiant cooling effect of the panel. Once again this is the most energy efficient method of providing cooling in comparison to other systems which rely on reducing the air temperature.

How much energy can be saved?

One of the most important considerations in selecting a heating and cooling system is the energy efficiency.

Zehnder radiant ceiling panels can save more than 40 % energy in comparison to other systems whilst achieving very comfortable room conditions.

There are two reasons for the significant energy saving: Since the perceived temperature is the average of the room air temperature and the surface temperatures (walls, ceiling, etc.), during heating, by increasing the surface temperatures the room air temperature can be reduced. Consequently there is a smaller difference between the room air temperature and the outside temperature and less heat loss through the fabric of the building (see Fig. 4 and 4a).

Additionally, with a very small temperature gradient over the height of the room energy is not wasted in a unoccupied space (see Fig. 1-3).

Potential energy savings of more than 40 % in comparison to other systems

- Air temperature can be up to 3 K lower (heating) or higher (cooling)
- Extremely low temperature stratification
- Short heating and cooling response
- Suitable for all energy sources including alternative energy sources such as heat pumps, condensing boilers or process waste heat

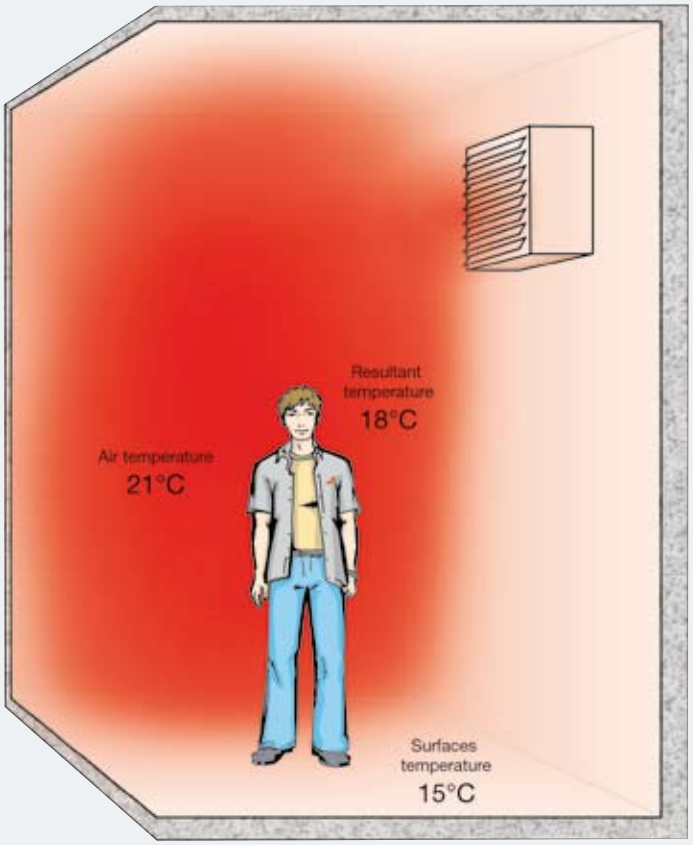


Fig. 4: Air heating

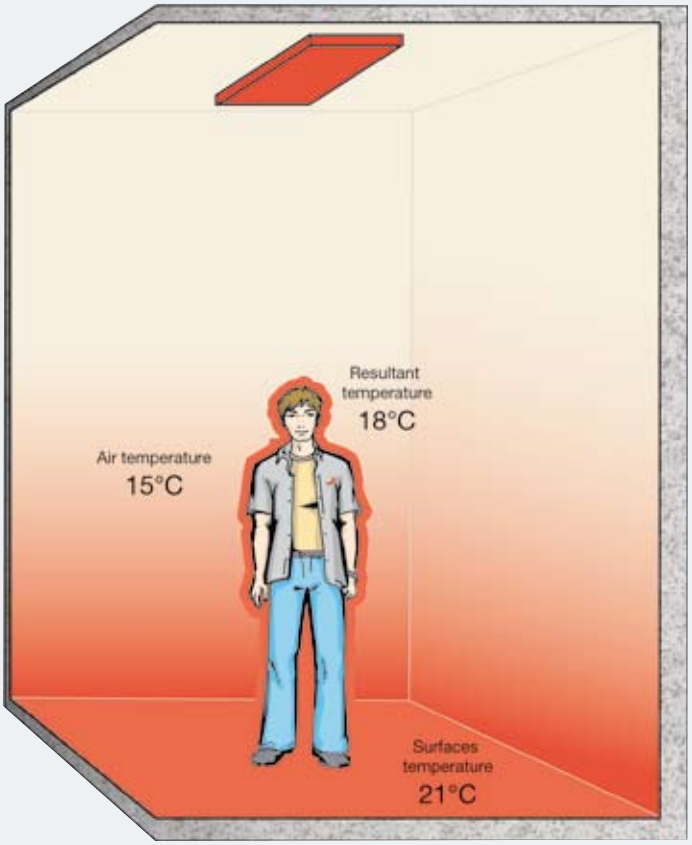


Fig. 4a: Radiant ceiling panels

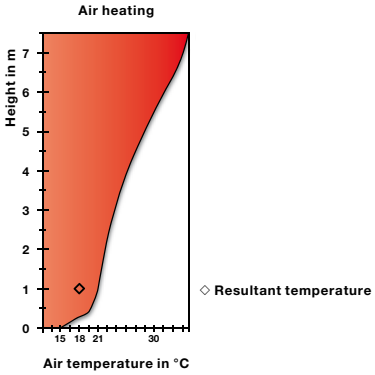


Fig. 1: Profile of the air temperature and globe temperature (at 1.0 m height) in a space with air heating.

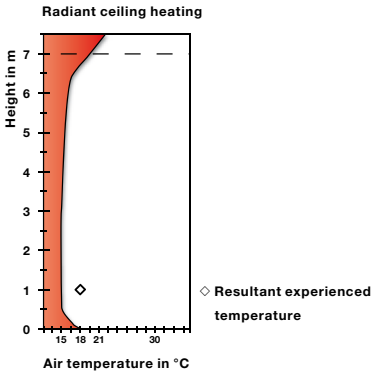


Fig. 2: Profile of the air temperature and globe temperature (at 1.0 m height) with Zehnder radiant ceiling panels.

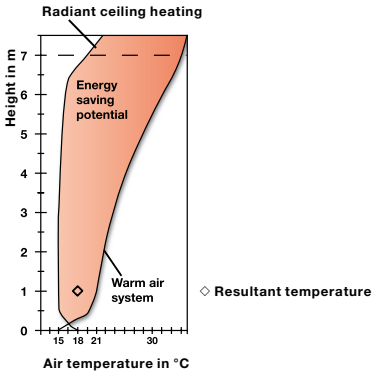
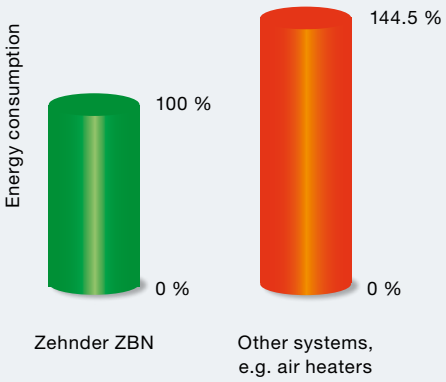


Fig. 3: Potential savings with radiant ceiling panel heating in comparison to air heating with the same globe temperature.

Example calculation energy saving

Potential energy saving with Zehnder ZBN: 44.5 %



Principles

Calculation formula according to DIN V 18599

$$\eta_{h,ce} = \frac{1}{4 - (\eta_L + \eta_C + \eta_B)} \quad Q_{h,ce,mth} = \left[\frac{f_{Radiant}\, f_{int}\, f_{hydr}}{\eta_{h,ce}} - 1\right] Q_{h,mth}$$

$Q_{h,ce,mth}$	Additional monthly heat requirement in kWh/mth
$Q_{h,mth}$	Monthly heat consumption in kWh/mth
f_{hydr}	Factor for flow balancing
f_{int}	Factor for intermittent operation
$f_{Radiant}$	Factor for the influence of radiation
$\eta_{h,ce}$	Total utilization ratio for the heat transfer in the room
η_L	Partial utilization ratio for the vertical air temperature profile
η_C	Partial utilization ratio for room temperature regulation
η_B	Partial utilization ratio for specific losses of the exterior components

Boundary conditions

Ceiling height 20 m, room temperature control of both systems by means of thermostatic control, air distribution with normal induction ratio, air outlet to the side

	f_{hydr}	f_{int}	$f_{Radiant}$	η_L	η_C	η_B
Zehnder ZBN	1.00	1.00	0.85	0.89	0.97	1.00
Air heating	1.00	1.00	1.00	0.63	0.97	1.00

Calculation

In the case of radiant ceiling panels, we obtain a factor of:

$Q_{h,ce,mth} = -0.031^{x} Q_{h,mth}$

With air heating, we obtain a factor of:

$Q_{h,ce,mth} = 0.400^{x} Q_{h,mth}$

Result

Energy saving with Zehnder ZBN radiant ceiling panels:

44.5 %

Joiner’s workshop Bauer, Vohburg (D)

Coffee Chicco d'Oro, Balerna (CH)

Why the investment is worthwhile

For the building owner, the initial capital equipment cost is often the greatest concern. However, ever increasing energy prices are now a significant factor and running costs of any heating or cooling system must be considered.

Investment costs
The investment costs for the heating and cooling of buildings depend on various conditions:

- Heating and cooling load
- System temperatures
- Energy distribution system
- Energy source
- Demands for comfort
- Building construction
- Architectural requirement
- etc.

Thanks to their high specific outputs, Zehnder ZBN radiant heating panels offer a decisive advantage with regard to their investment costs. With minimal surface areas, the maximum output is achieved – at optimum comfort levels, with aesthetics to compliment the application.

Energy costs
The energy costs depend mainly on the type of the system and the energy source. The biggest cost factor is an inefficient heat distribution in the room. If, in addition, a system requires driving energy, e.g. for fans, there are additional electrical power costs. In the case of variants such as air systems or gas radiators, there are additional expenses from maintenance and upkeep.

Zehnder ZBN radiant ceiling panels are particularly efficient, saving more than 40 % energy in comparison to other systems. Numerous installations of Zehnder ZBN proove this fact daily.

The cost benefits at a glance:

- More than 40 % energy saving is possible
- No extra power costs for forced heat distribution
- No cost for maintenance and upkeep
- High specific outputs of the radiant ceiling panels

How comfortable can a building be?

People must feel comfortable inside buildings.

Thousands of years ago, the Romans developed the hypocaust system of heating. This was effectively a radiant heating system which gave high levels of comfort.

A look at nature also helps us to understand this heating system better. Anyone standing in the sun on a cold winter day can feel the radiant heat of the sun, even though the surrounding air is cold.

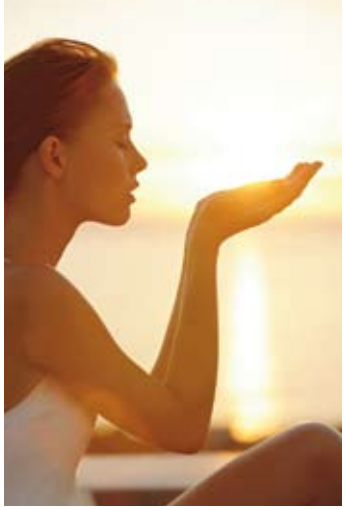
Zehnder radiant ceiling panels employ the same principle and therefore provide high comfort levels.

Zehnder radiant panels are positioned to give a comfortable heat distribution throughout the space. The temperature over the height of the room also remains almost constant, providing an ideal indoor climate.

Zehnder radiant panel heating creates very little air turbulence and therefore no dust circulation in the atmosphere. Consequently it is a very clean and hygienic form of heating. In dirty environments this can dramatically reduce cleaning bills and maintain the efficiency of machines whilst also offering health benefits to occupants.

Benefits for personal comfort

- The principle of radiant heat
- Uniform heat distribution in the space
- Uniform temperature distribution over the height of the space
- Heating and cooling action can be felt immediately
- No dust circulation



Combination with other systems

In certain buildings, such as sports halls or event halls, the required minimum air replacement has to be achieved using a ventilation system. This system carries away pollutantladen air out of the building and brings in fresh air.

In these cases too, Zehnder ZBN radiant ceiling panels can be deployed without any problem.

Important: In case of a combination of ventilation system and Zehnder ZBN, the air replacement rate should be restricted to the minimum necessary. Heating and cooling should be achieved solely by the radiant ceiling panels to optimize the numerous benefits.

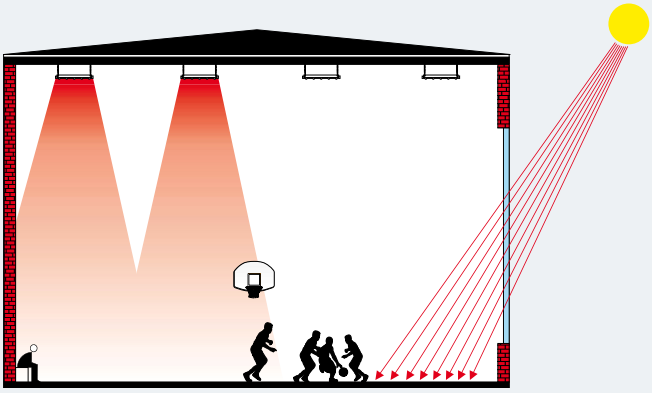


Fig. 1: Zehnder ZBN radiant heating panels in sports halls without additional ventilation system: no drafts through cold outer walls, free choice of flooring, for example, with sports mats.

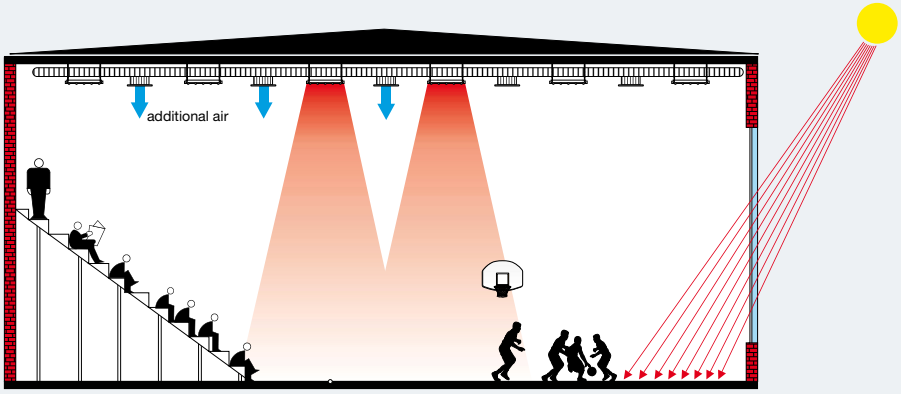


Fig. 2: Zehnder ZBN radiant ceiling panels in sports halls with spectators, with additional ventilation system: Zehnder ZBN heats the hall, the ventilation system takes care of fresh air.

What is the structure of Zehnder ZBN in detail?

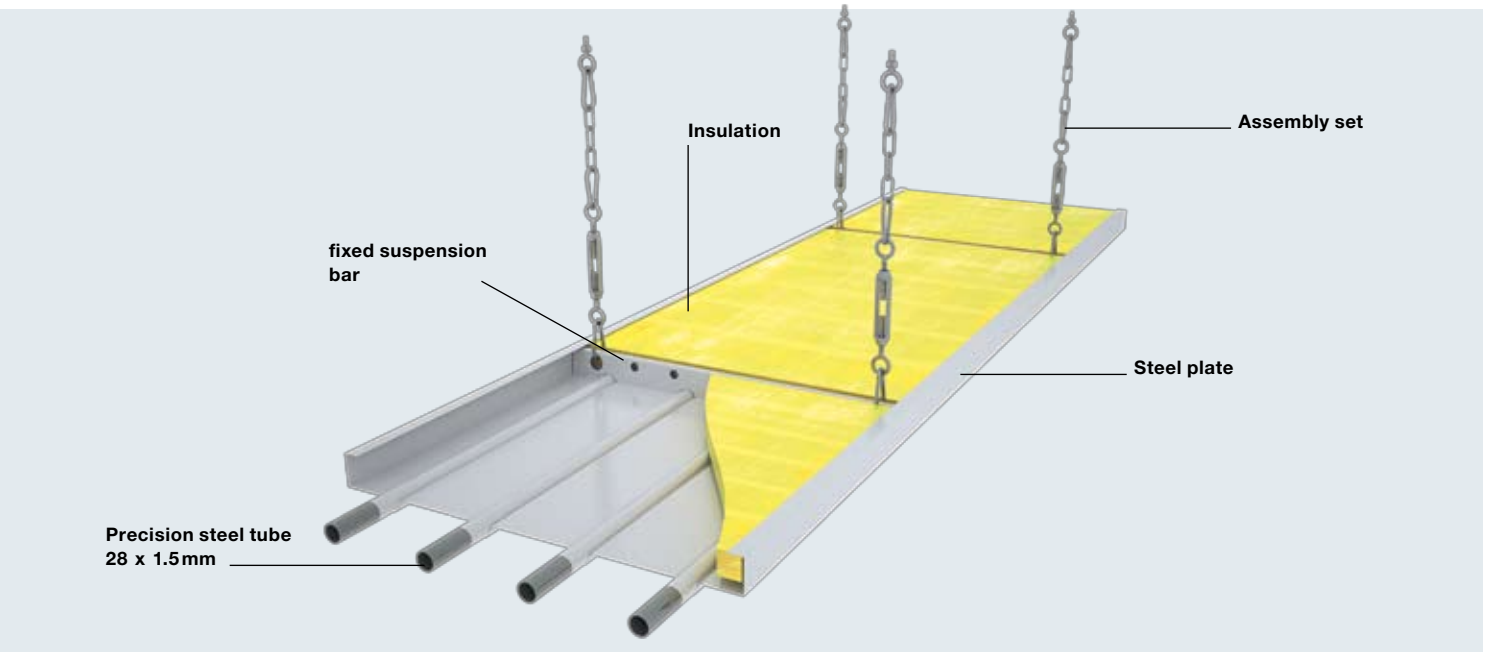
Zehnder stands for quality, functionality and design. The company is certified according to ISO 9001 and manufactures according to the strictest quality guidelines. Zehnder ZBN radiant ceiling panels are manufactured and inspected in accordance with the EN 14037 standard. They carry the CE mark.

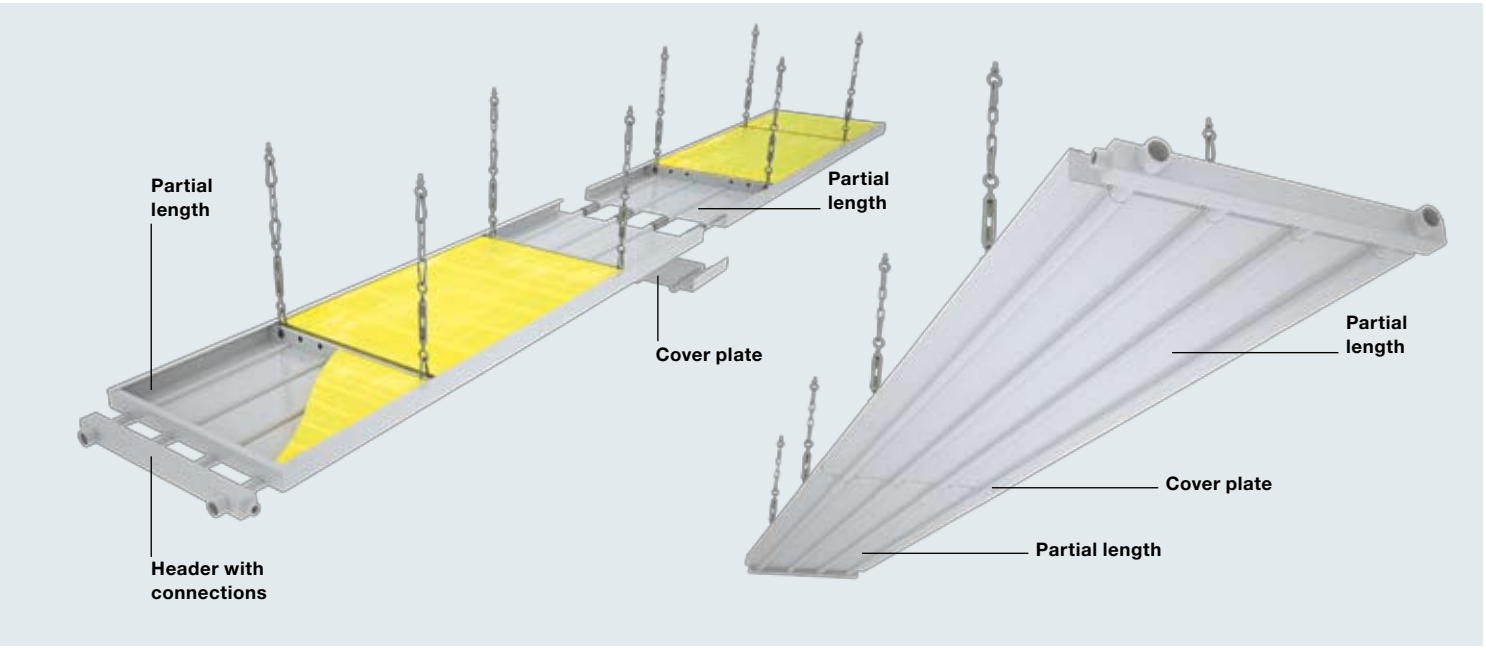
Construction of the heating / cooling panel
The Zehnder ZBN radiant ceiling panels consist of a steel radiant plate with deep-drawn lock beading for locating the tubes. Precision steel tubes (Ø 28 x 1.5 mm) are continuously welded with the radiant plate in a special double-spot welding process. This guarantees an ideal heat transfer and the highest efficiency values. The headers are made of rectangular section tube 45 x 45 mm and are fitted with all the necessary connections and diverters. The radiant ceiling panels are statically self-supporting due the side and top edges (strength tested by the Materials Testing Institute of the University of Stuttgart). The edge profiles contain the insulation which is located on the topside of the panels. The insulation provides a heat barrier and can also absorb sound (particularly effective when the panel is perforated).

For fixing to the ceiling, suspension points are welded at the factory. Optionally, variable hanging points are also available for fixing by the customer at the required position on site.

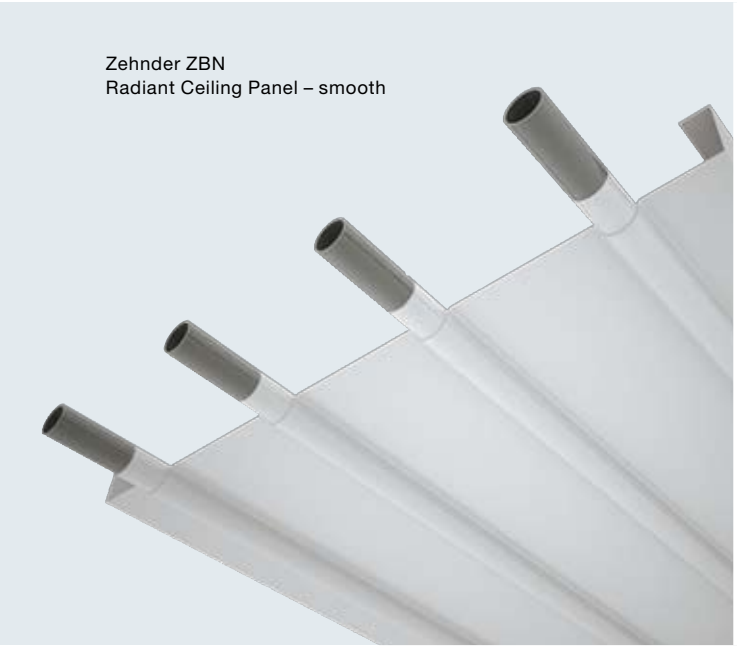
Models
Zehnder ZBN radiant ceiling panels were specially developed for heating and cooling buildings with any room height. Standard widths are 300, 450, 600, 750, 900, 1050 and 1200 mm. In addition, there are a large number of special sizes, which are made up of the standard widths. A radiant ceiling panel run can consist of several individual panels that are joined together in series. The individual panels can be manufactured up to a length of 7.5 m (this length is unique in Europe and reduces the assembly costs by up to 20 % as compared to a standard length of 6 m). The individual panels are combined by means of welded joints or crimp fittings into the desired designs and the joints are hidden by cover plates. The continous appearance is thus retained. The total length of the run (up to 120 m) is manufactured according to requirement. This combination of panel widths and lengths will cover all possible applications such as: Factories, storage facilities, sports and multipurpose halls, schools, home improvement stores and malls, showrooms etc.

Surface options
The Zehnder ZBN radiant ceiling panels are available with either a smooth or an optional perforated surface. The surface is coated with a high-quality powder coat finish (standard colour RAL 9016 or a colour shade of your choosing).



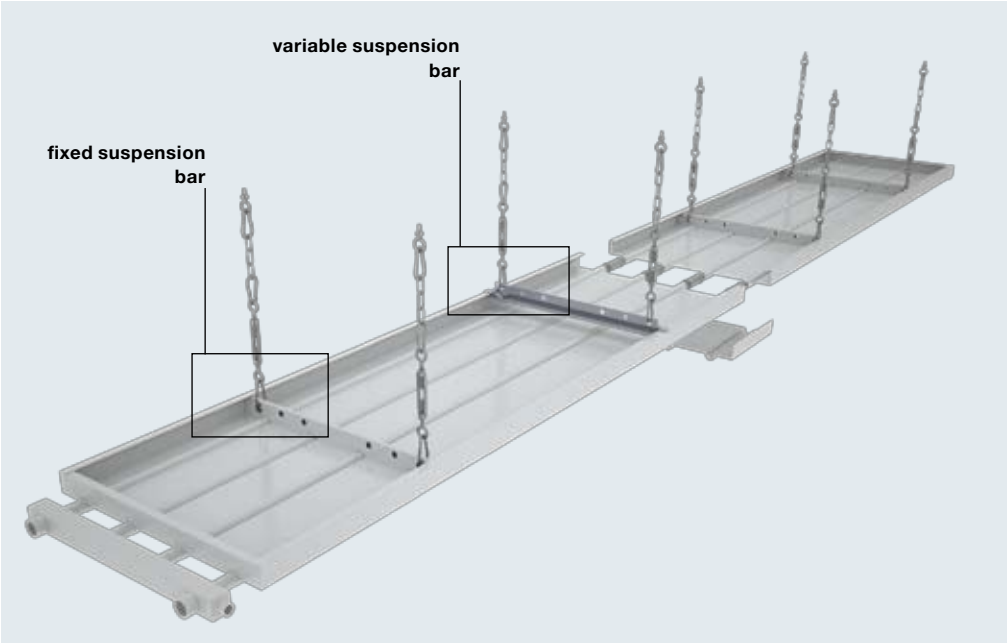


Zehnder ZBN
Radiant Ceiling Panel – smooth

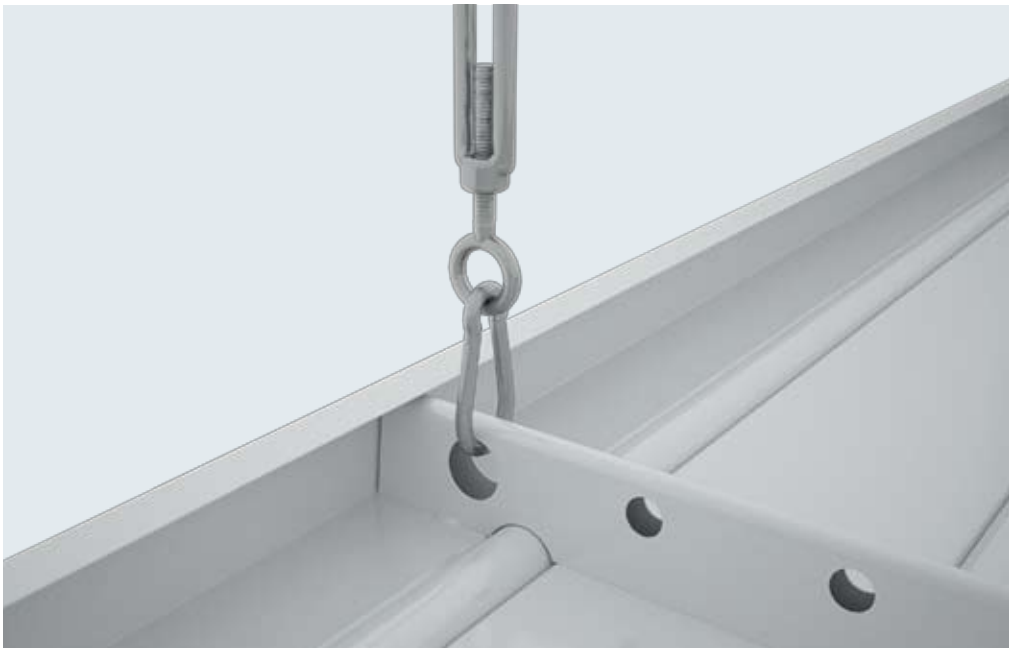


Zehnder ZBN
Radiant Ceiling Panel – perforated

Suspension and fixing



The Zehnder ZBN radiant ceiling panel can be suspended in two ways.



Fixed suspension bar
Here, the fastening points are at a fixed place in the panel and cannot be moved.

Variable suspension bar
These can be moved along the length of the panel to suit conditions on site.

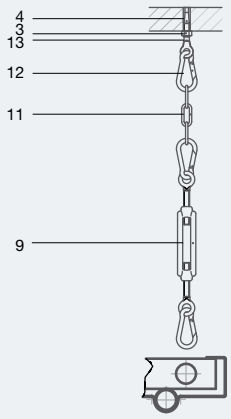
Arminius market hall, Berlin (D)

Assembly sets

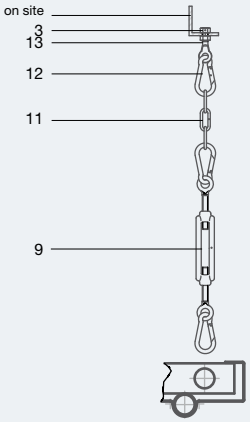
Standard assembly sets
For installing the radiant ceiling panels on the ceiling, there are 5 standard assembly sets. Special solutions can be provided to suit if required.

Legend
3 hexagonal nut
4 steel dowel
5 girder clamp
6 safety stop
7 flat leaf bolt
8 trapezoid hanger bracket
9 turnbuckle with 2 eyelets
11 link chain
12 spring hook
13 eyebolt
14 sing washer
15 hexagonal head screw

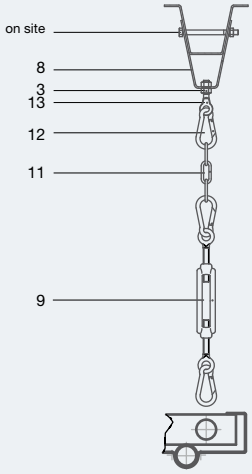
Concrete ceiling
Assembly set K33



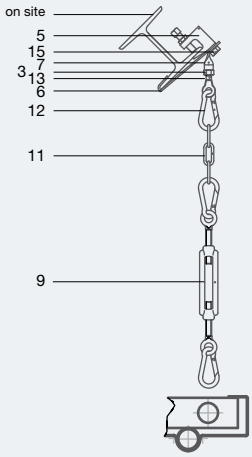
Sectional steel
Assembly set K34



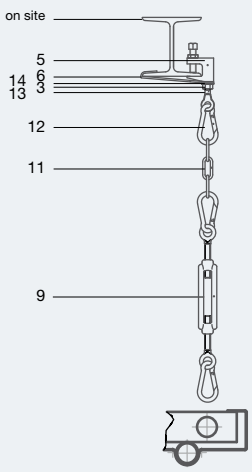
Trapezoidal sheeting
Assembly set K36



Inclined steel girder
Assembly set K37



Horizontal steel girder
Assembly set K38



Joining methods

Where a single run is made up of two or more panels it is necessary to join them together. The tubes can be joined in two ways.

Welded joint
The welded joint can be used universally and is suitable for all temperatures, all panel widths and lengths as well as all types of hydraulic joints. The tubes are butt-jointed and welded alternately from the outside to the inside.

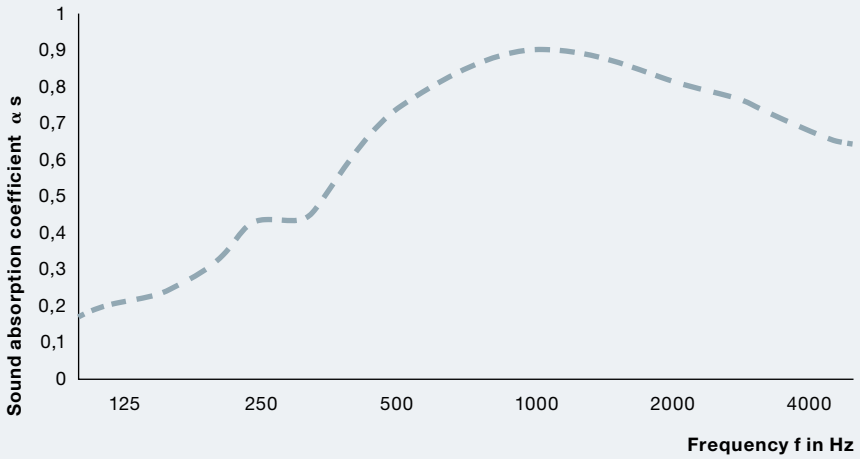
Crimp fittings
There are limits to the applications of crimp fittings, since in the extreme case, they cannot withstand the force of expansion of the radiant panels. In the long term, this would result in leaks. For this reason, Zehnder, in collaboration with a renowned company working in the area of „finite elements“, has developed a program which makes the use of crimp fittings possible.

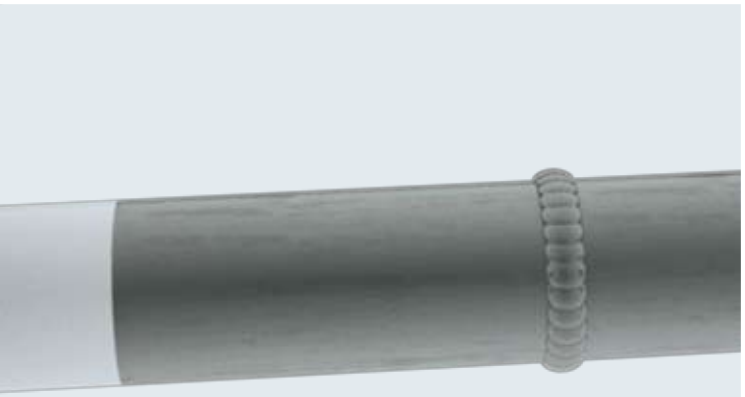
By means of this exclusive program, Zehnder checks the configuration of the radiant ceiling panels to be used and supplies the corresponding crimp fittings. This ensures that the press fitting remains tight in operation.

Sound absorption

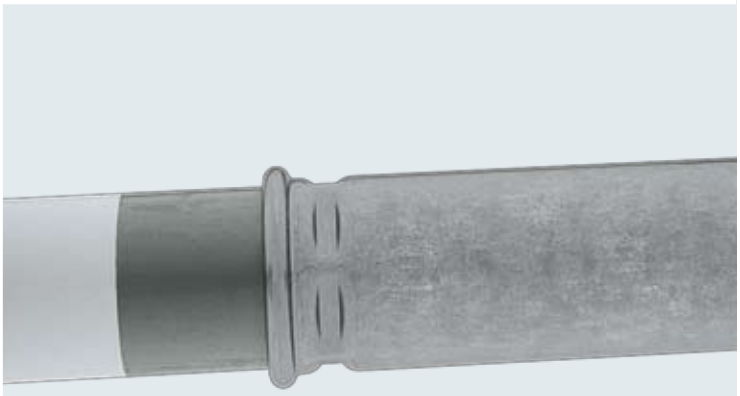
Regardless of their heating or cooling action, Zehnder radiant ceiling panels can also be used for sound absorption: The sound waves reach the inserted heat insulation through the perforation in the radiant panels and are absorbed. A significant reduction in the sound level or a reduction in the reverberation time can thus be achieved (for example, in gymnasiums and sports halls). There is detailed data available upon enquiry for the calculation of the acoustics performance.

Zehnder ZBN sound absorption coefficient in relation to the frequency

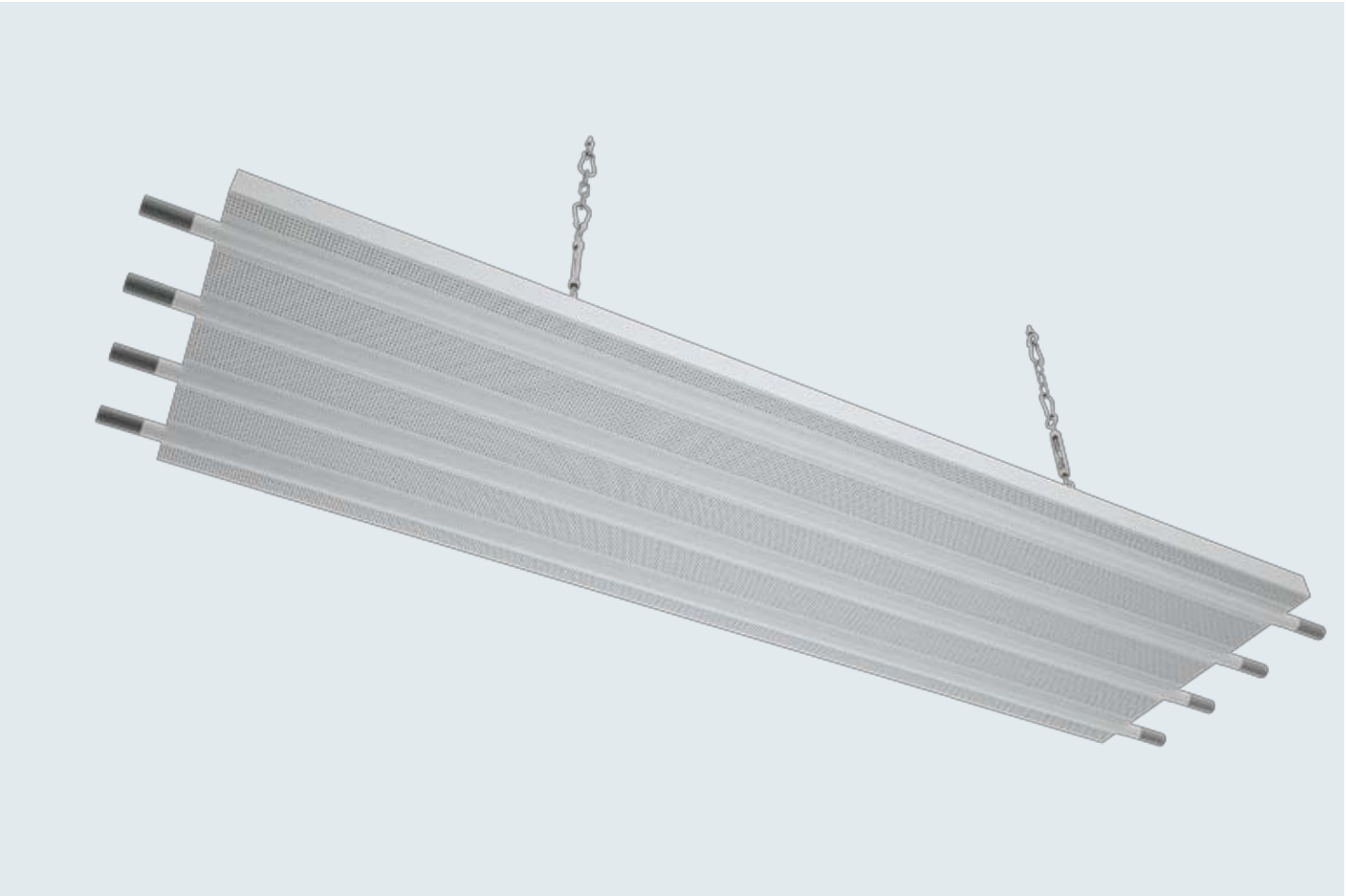




Welded joint

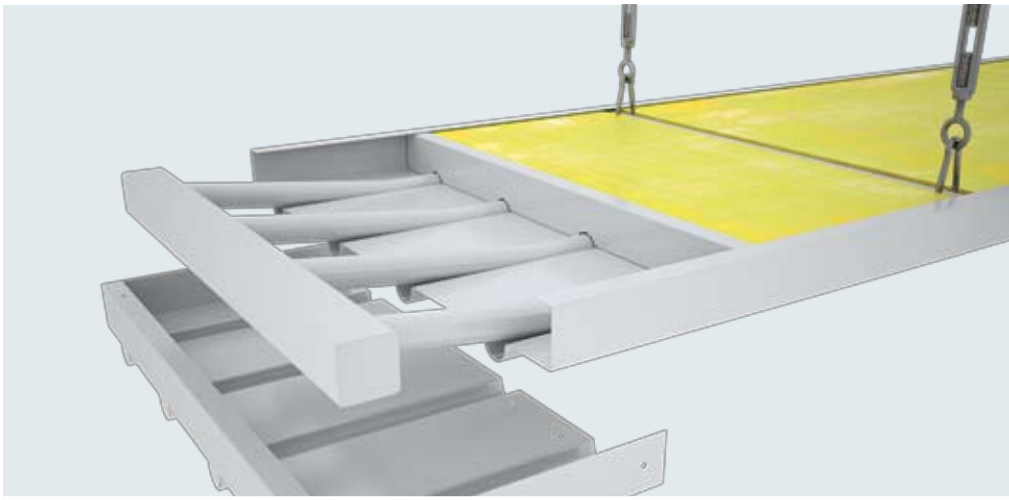


Crimp fitting



Special solutions

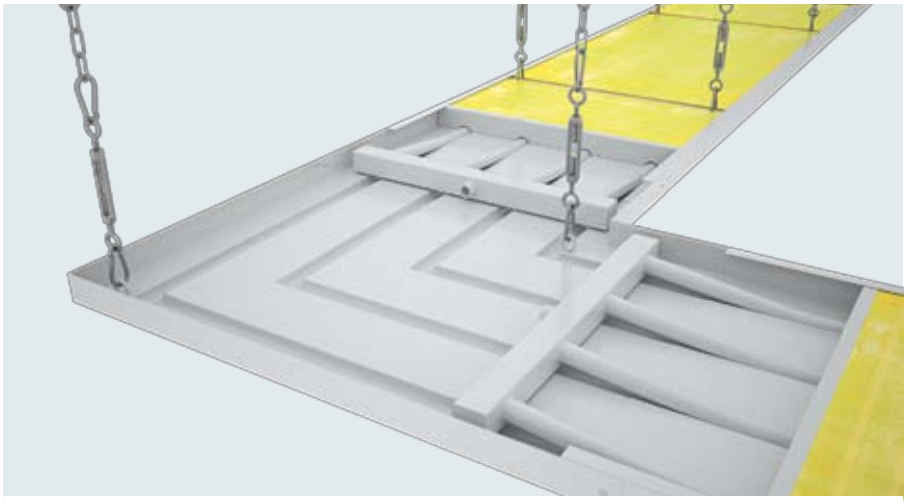
Zehnder ZBN radiant ceiling panels are extremely versatile: apart from the wide-ranging standard models, there are numerous special solutions to satisfy the requirements of every installation and project.



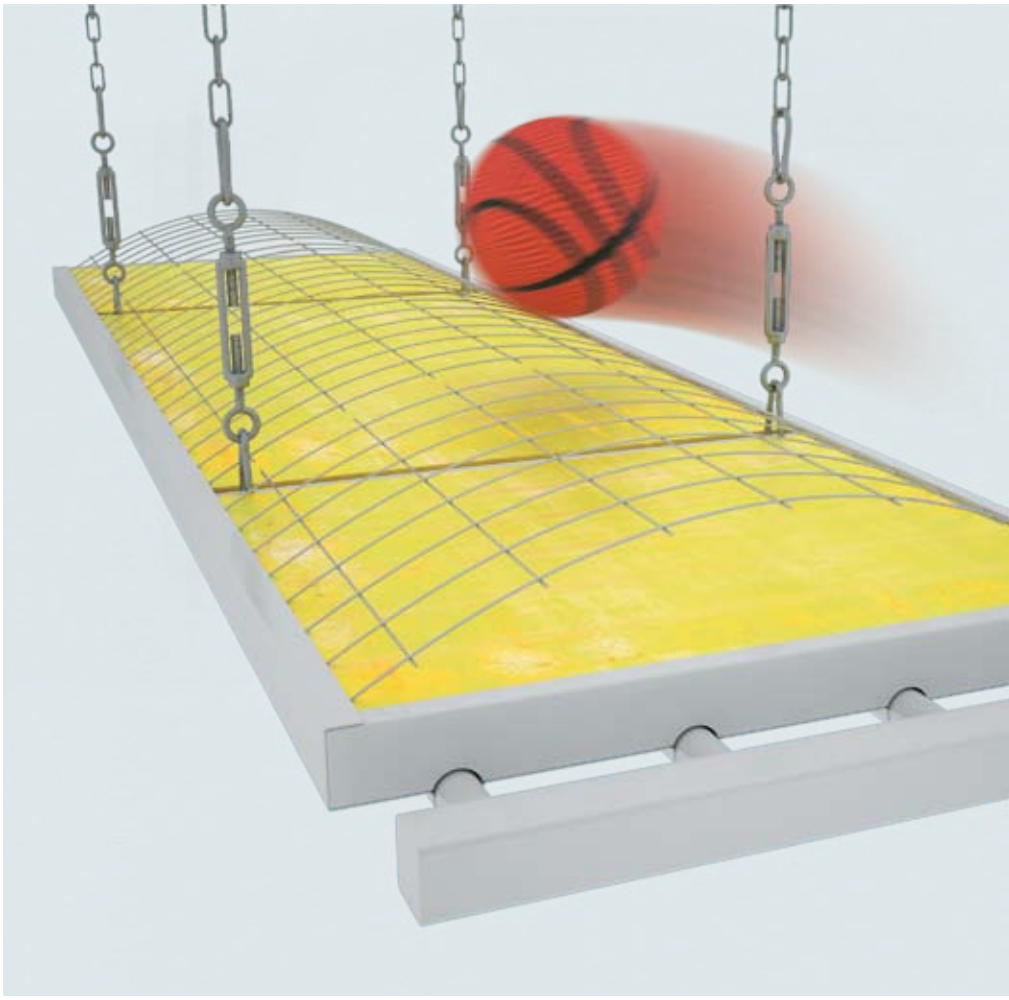
Cover plates
The headers are hidden by end cover plates.

Interrupted radiant panel
This variation allows the unrestricted passage of light, e.g. in the case of skylights.

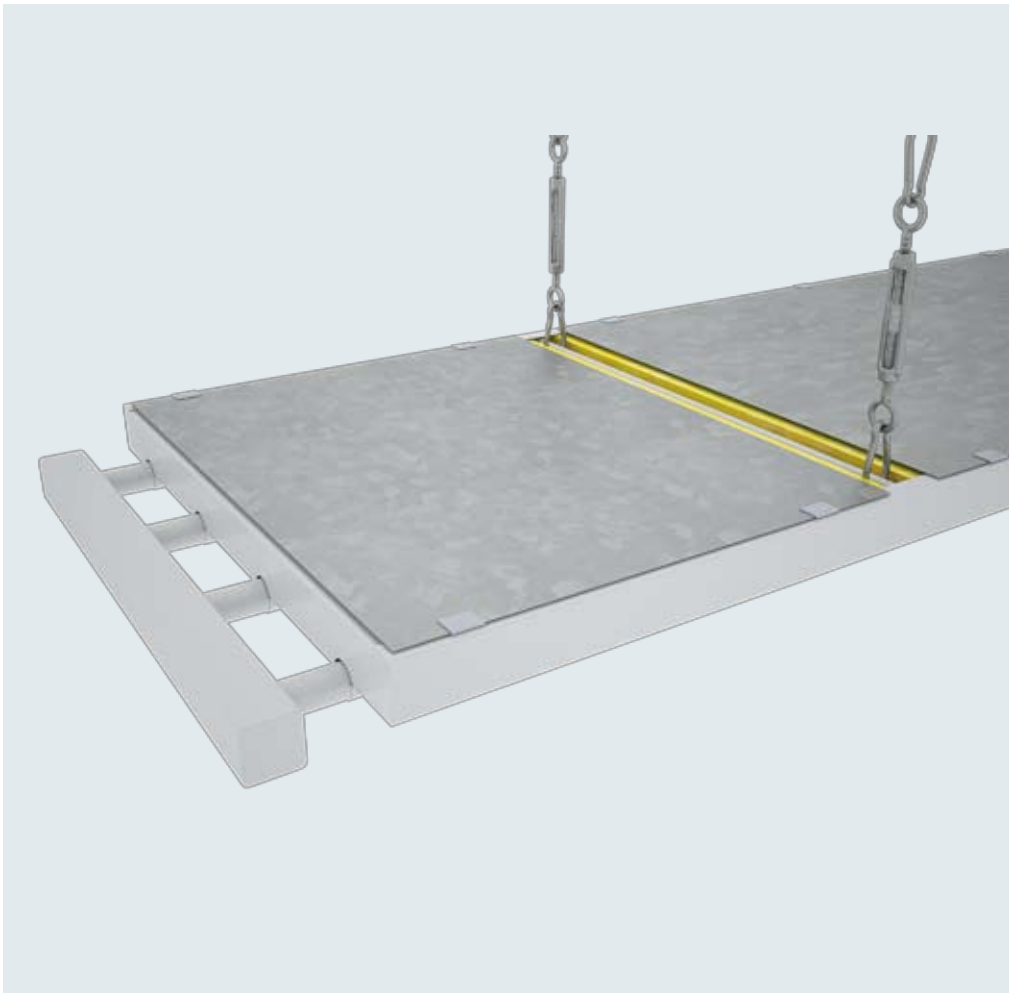
Integration of lights, etc.
For locating different fittings, e.g. lights, fire alarms, loudspeakers etc., cutouts can be provided in the radiant plate.



Mitre corners
To blend with the architecture – or as a design element – Zehnder ZBN radiant ceiling panels can also be manufactured angled or with mitre corners.



Ball guards
The galvanized ball guards prevent balls from remaining on top of the radiant ceiling panels in sports halls.



Dust protection back plate
For some applications where hygiene is a consideration, a dust protection back plate can be fitted allowing the rear of the panel to be cleaned without any problems.

Scholl sports hall, Offenburg (D)

Munich-Riem airport, entrance hall, Munich (D)

Logistics

Transport and delivery
Zehnder ZBN radiant ceiling panels are delivered by lorry. Depending on the type and length, a pallet contains 4-6 panels (max. 1500 kg).

Transport protection
As standard, Zehnder ZBN radiant ceiling panels are stacked on top of one another and secured with bands. If required, each panel can be protected in plastic foil. Individual panels (up to 2 panels) are supplied in a wooden crate.

Unloading
A delivery date is agreed with the customer so that the customer can ensure that suitable equipment and personal are available on site for unloading (a crane is the most suitable way of unloading). Cross beams as well as belts (not delivered by Zehnder) guarentees that the packages can be unloaded quickly and safely.

Zehnder ZBN product advantages

Zehnder ZBN radiant ceiling panels are a cost-effective, economic, environment-friendly and energy-saving alternative for buildings of any height. The advantages at a glance.

Economic viability

- More than 40% energy saving is possible
- Air temperature is up to 3 K lower (heating) or higher (cooling)
- Extremely low temperature stratification
- Short heating and cooling response times
- Suitable for all energy sources including alternative energies such as heat pumps, condensing appliance technology or process waste heat
- No additional power costs for heat distribution
- No costs for maintenance and upkeep
- High efficiency of the radiant ceiling panels

Benefits for personal comfort

- The principle of radiant heat
- Uniform heat distribution in the space
- Uniform temperature distribution over the height of the space
- Heating and cooling action can be felt immediately
- No dust circulation
- Absolutely silent operation

Technology

- High heating and cooling capacities (according to EN 14037 or based on EN 14240)
- Unrestricted use of the floor and wall surfaces
- Extremely fast reaction times of the system to temperature changes
- Simple mounting. Cost savings up to 20 % in case of individual element 7.5 m
- Thermal insulation factory fitted

Product variety

- 7 standard Zehnder ZBN models (2 to 8 tubes) width 300 to 1200 mm
- Length of the runs up to 120 m (partial length up to 7.5 m)
- High quality powder coating in all colour shades
- Special solutions tailored individually according to customer requirements
- Perforated design for sound absorption

Ice stadium, Küssnacht (CH)

Parish church of St. Augustinus, Munich (D)

Technical Design Data

Explanation of symbols	
t_L	air temperature (°C)
t_U	surrounding surface temperature (°C) = average surface temperature of all the surrounding surfaces (°C)
$t_i = t_E$	inside temperature (°C) = resulting temperature (°C)
t_{HVL}	heat flow temperature (°C)
t_{HRL}	heat return temperature (°C)
t_{KVL}	cold flow temperature (°C)
t_{KRL}	cold return temperature (°C)
$\triangle t_{Über}$	temperature difference heating (K)
$\triangle t_{Unter}$	temperature difference cooling (K)

Physical units
degrees Celsius (°C)
Kelvin (K)
cubic metres (m^3)
metres (m)
millimetres (mm)
Pascal (Pa)
Kilogram (kg)

Temperature difference (heating)

The temperature difference can be calculated arithmetically or taken from the following table.

$$t_i = t_E = \frac{(t_u + t_L)}{2}$$

$$\triangle t_{Über} = \frac{(t_{HVL} + t_{HRL})}{2} - t_i$$

t_{HVL} °C		120	115	110	105	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	t_{HVL} °C	
t_{HRL} °C	t_i °C																					t_i °C	t_{HRL} °C
	10	107.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	
	12	105.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	
115	15	102.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	115
	18	99.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	
	20	97.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	
	10	105.0	102.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	
	12	103.0	100.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	
110	15	100.0	97.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	110
	18	97.0	94.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	
	20	95.0	92.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	
	10	102.5	100.0	97.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	
	12	100.5	98.0	95.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	
105	15	97.5	95.0	92.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	105
	18	94.5	92.0	89.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	
	20	92.5	90.0	87.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	
	10	100.0	97.5	95.0	92.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	
	12	98.0	95.5	93.0	90.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	
100	15	95.0	92.5	90.0	87.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	100
	18	92.0	89.5	87.0	84.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	
	20	90.0	87.5	85.0	82.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	
	10	97.5	95.0	92.5	90.0	87.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	
	12	95.5	93.0	90.5	88.0	85.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	
95	15	92.5	90.0	87.5	85.0	82.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	95
	18	89.5	87.0	84.5	82.0	79.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	
	20	87.5	85.0	82.5	80.0	77.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	
	10	95.0	92.5	90.0	87.5	85.0	82.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	
	12	93.0	90.5	88.0	85.5	83.0	80.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	
90	15	90.0	87.5	85.0	82.5	80.0	77.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	90
	18	87.0	84.5	82.0	79.5	77.0	74.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	
	20	85.0	82.5	80.0	77.5	75.0	72.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	
	10	92.5	90.0	87.5	85.0	82.5	80.0	77.5	-	-	-	-	-	-	-	-	-	-	-	-	-	10	
	12	90.5	88.0	85.5	83.0	80.5	78.0	75.5	-	-	-	-	-	-	-	-	-	-	-	-	-	12	
85	15	87.5	85.0	82.5	80.0	77.5	75.0	72.5	-	-	-	-	-	-	-	-	-	-	-	-	-	15	85
	18	84.5	82.0	79.5	77.0	74.5	72.0	69.5	-	-	-	-	-	-	-	-	-	-	-	-	-	18	
	20	82.5	80.0	77.5	75.0	72.5	70.0	67.5	-	-	-	-	-	-	-	-	-	-	-	-	-	20	
	10	90.0	87.5	85.0	82.5	80.0	77.5	75.0	72.5	-	-	-	-	-	-	-	-	-	-	-	-	10	
	12	88.0	85.5	83.0	80.5	78.0	75.5	73.0	70.5	-	-	-	-	-	-	-	-	-	-	-	-	12	
80	15	85.0	82.5	80.0	77.5	75.0	72.5	70.0	67.5	-	-	-	-	-	-	-	-	-	-	-	-	15	80
	18	82.0	79.5	77.0	74.5	72.0	69.5	67.0	64.5	-	-	-	-	-	-	-	-	-	-	-	-	18	
	20	80.0	77.5	75.0	72.5	70.0	67.5	65.0	62.5	-	-	-	-	-	-	-	-	-	-	-	-	20	
	10	87.5	85.0	82.5	80.0	77.5	75.0	72.5	70.0	67.5	-	-	-	-	-	-	-	-	-	-	-	10	
	12	85.5	83.0	80.5	78.0	75.5	73.0	70.5	68.0	65.5	-	-	-	-	-	-	-	-	-	-	-	12	
75	15	82.5	80.0	77.5	75.0	72.5	70.0	67.5	65.0	62.5	-	-	-	-	-	-	-	-	-	-	-	15	75
	18	79.5	77.0	74.5	72.0	69.5	67.0	64.5	62.0	59.5	-	-	-	-	-	-	-	-	-	-	-	18	
	20	77.5	75.0	72.5	70.0	67.5	65.0	62.5	60.0	57.5	-	-	-	-	-	-	-	-	-	-	-	20	
	10	85.0	82.5	80.0	77.5	75.0	72.5	70.0	67.5	65.0	62.5	-	-	-	-	-	-	-	-	-	-	10	
	12	83.0	80.5	78.0	75.5	73.0	70.5	68.0	65.5	63.0	60.5	-	-	-	-	-	-	-	-	-	-	12	
70	15	80.0	77.5	75.0	72.5	70.0	67.5	65.0	62.5	60.0	57.5	-	-	-	-	-	-	-	-	-	-	15	70
	18	77.0	74.5	72.0	69.5	67.0	64.5	62.0	59.5	57.0	54.5	-	-	-	-	-	-	-	-	-	-	18	
	20	75.0	72.5	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	-	-	-	-	-	-	-	-	-	-	20	
t_{HRL} °C	t_i °C																					t_i °C	t_{HRL} °C
t_{HVL} °C		120	115	110	105	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	t_{HVL} °C	

t_{HVL} °C		120	115	110	105	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	t_{HVL} °C	
t_{HRL} °C	t_i °C																					t_i °C	t_{HRL} °C
	10	82.5	80.0	77.5	75.0	72.5	70.0	67.5	65.0	62.5	60.0	57.5	-	-	-	-	-	-	-	-	-	10	
	12	80.5	78.0	75.5	73.0	70.5	68.0	65.5	63.0	60.5	58.0	55.5	-	-	-	-	-	-	-	-	-	12	
65	15	77.5	75.0	72.5	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	-	-	-	-	-	-	-	-	-	15	65
	18	74.5	72.0	69.5	67.0	64.5	62.0	59.5	57.0	54.5	52.0	49.5	-	-	-	-	-	-	-	-	-	18	
	20	72.5	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	-	-	-	-	-	-	-	-	-	20	
	10	80.0	77.5	75.0	72.5	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	-	-	-	-	-	-	-	-	10	
	12	78.0	75.5	73.0	70.5	68.0	65.5	63.0	60.5	58.0	55.5	53.0	50.5	-	-	-	-	-	-	-	-	12	
60	15	75.0	72.5	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	-	-	-	-	-	-	-	-	15	60
	18	72.0	69.5	67.0	64.5	62.0	59.5	57.0	54.5	52.0	49.5	47.0	44.5	-	-	-	-	-	-	-	-	18	
	20	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	-	-	-	-	-	-	-	-	20	
	10	77.5	75.0	72.5	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	-	-	-	-	-	-	-	10	
	12	75.5	73.0	70.5	68.0	65.5	63.0	60.5	58.0	55.5	53.0	50.5	48.0	45.5	-	-	-	-	-	-	-	12	
55	15	72.5	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	-	-	-	-	-	-	-	15	55
	18	69.5	67.0	64.5	62.0	59.5	57.0	54.5	52.0	49.5	47.0	44.5	42.0	39.5	-	-	-	-	-	-	-	18	
	20	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	-	-	-	-	-	-	-	20	
	10	75.0	72.5	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	-	-	-	-	-	-	10	
	12	73.0	70.5	68.0	65.5	63.0	60.5	58.0	55.5	53.0	50.5	48.0	45.5	43.0	40.5	-	-	-	-	-	-	12	
50	15	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	-	-	-	-	-	-	15	50
	18	67.0	64.5	62.0	59.5	57.0	54.5	52.0	49.5	47.0	44.5	42.0	39.5	37.0	34.5	-	-	-	-	-	-	18	
	20	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	-	-	-	-	-	-	20	
	10	72.5	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	-	-	-	-	-	10	
	12	70.5	68.0	65.5	63.0	60.5	58.0	55.5	53.0	50.5	48.0	45.5	43.0	40.5	38.0	35.5	-	-	-	-	-	12	
45	15	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	-	-	-	-	-	15	45
	18	64.5	62.0	59.5	57.0	54.5	52.0	49.5	47.0	44.5	42.0	39.5	37.0	34.5	32.0	29.5	-	-	-	-	-	18	
	20	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	-	-	-	-	-	20	
	10	70.0	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	-	-	-	-	10	
	12	68.0	65.5	63.0	60.5	58.0	55.5	53.0	50.5	48.0	45.5	43.0	40.5	38.0	35.5	33.0	30.5	-	-	-	-	12	
40	15	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	-	-	-	-	15	40
	18	62.0	59.5	57.0	54.5	52.0	49.5	47.0	44.5	42.0	39.5	37.0	34.5	32.0	29.5	27.0	24.5	-	-	-	-	18	
	20	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	-	-	-	-	20	
	10	67.5	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	-	-	-	10	
	12	65.5	63.0	60.5	58.0	55.5	53.0	50.5	48.0	45.5	43.0	40.5	38.0	35.5	33.0	30.5	28.0	25.5	-	-	-	12	
35	15	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	-	-	-	15	35
	18	59.5	57.0	54.5	52.0	49.5	47.0	44.5	42.0	39.5	37.0	34.5	32.0	29.5	27.0	24.5	22.0	19.5	-	-	-	18	
	20	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	20.0	17.5	-	-	-	20	
	10	65.0	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	-	-	10	
	12	63.0	60.5	58.0	55.5	53.0	50.5	48.0	45.5	43.0	40.5	38.0	35.5	33.0	30.5	28.0	25.5	23.0	20.5	-	-	12	
30	15	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	20.0	17.5	-	-	15	30
	18	57.0	54.5	52.0	49.5	47.0	44.5	42.0	39.5	37.0	34.5	32.0	29.5	27.0	24.5	22.0	19.5	17.0	14.5	-	-	18	
	20	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	20.0	17.5	15.0	12.5	-	-	20	
	10	62.5	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	20.0	17.5	-	10	
	12	60.5	58.0	55.5	53.0	50.5	48.0	45.5	43.0	40.5	38.0	35.5	33.0	30.5	28.0	25.5	23.0	20.5	18.0	15.5	-	12	
25	15	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	20.0	17.5	15.0	12.5	-	15	25
	18	54.5	52.0	49.5	47.0	44.5	42.0	39.5	37.0	34.5	32.0	29.5	27.0	24.5	22.0	19.5	17.0	14.5	12.0	9.5	-	18	
	20	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	20.0	17.5	15.0	12.5	10.0	7.5	-	20	
	10	60.0	57.5	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	20.0	17.5	15.0	12.5	10	
	12	58.0	55.5	53.0	50.5	48.0	45.5	43.0	40.5	38.0	35.5	33.0	30.5	28.0	25.5	23.0	20.5	18.0	15.5	13.0	10.5	12	
20	15	55.0	52.5	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	20.0	17.5	15.0	12.5	10.0	7.5	15	20
	18	52.0	49.5	47.0	44.5	42.0	39.5	37.0	34.5	32.0	29.5	27.0	24.5	22.0	19.5	17.0	14.5	12.0	9.5	7.0	4.5	18	
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	
t_{HRL} °C	t_i °C																					t_i °C	t_{HRL} °C
t_{HVL} °C		120	115	110	105	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	t_{HVL} °C	

Temperature difference (cooling)

Just like the temperature difference for heating, the temperature difference for cooling can also be calculated arithmetically or taken from the following table.

$$t_i = t_E = \frac{(t_u + t_L)}{2}$$

$$\triangle t_{Unter} = t_i - \frac{(t_{KVL} + t_{KRL})}{2}$$

t_{KVL} °C		14	15	16	17	18	19	20	21	22	23	24	t_{KVL} °C	
t_{KRL} °C	t_i °C												t_i °C	t_{KRL} °C
15	22	7.5	-	-	-	-	-	-	-	-	-	-	22	15
	23	8.5	-	-	-	-	-	-	-	-	-	-	23	
	24	9.5	-	-	-	-	-	-	-	-	-	-	24	
	25	10.5	-	-	-	-	-	-	-	-	-	-	25	
	26	11.5	-	-	-	-	-	-	-	-	-	-	26	
16	22	7.0	6.5	-	-	-	-	-	-	-	-	-	22	16
	23	8.0	7.5	-	-	-	-	-	-	-	-	-	23	
	24	9.0	8.5	-	-	-	-	-	-	-	-	-	24	
	25	10.0	9.5	-	-	-	-	-	-	-	-	-	25	
	26	11.0	10.5	-	-	-	-	-	-	-	-	-	26	
17	22	6.5	6.0	5.5	-	-	-	-	-	-	-	-	22	17
	23	7.5	7.0	6.5	-	-	-	-	-	-	-	-	23	
	24	8.5	8.0	7.5	-	-	-	-	-	-	-	-	24	
	25	9.5	9.0	8.5	-	-	-	-	-	-	-	-	25	
	26	10.5	10.0	9.5	-	-	-	-	-	-	-	-	26	
18	22	6.0	5.5	5.0	4.5	-	-	-	-	-	-	-	22	18
	23	7.0	6.5	6.0	5.5	-	-	-	-	-	-	-	23	
	24	8.0	7.5	7.0	6.5	-	-	-	-	-	-	-	24	
	25	9.0	8.5	8.0	7.5	-	-	-	-	-	-	-	25	
	26	10.0	9.5	9.0	8.5	-	-	-	-	-	-	-	26	
19	22	5.5	5.0	4.5	4.0	3.5	-	-	-	-	-	-	22	19
	23	6.5	6.0	5.5	5.0	4.5	-	-	-	-	-	-	23	
	24	7.5	7.0	6.5	6.0	5.5	-	-	-	-	-	-	24	
	25	8.5	8.0	7.5	7.0	6.5	-	-	-	-	-	-	25	
	26	9.5	9.0	8.5	8.0	7.5	-	-	-	-	-	-	26	
20	22	5.0	4.5	4.0	3.5	3.0	2.5	-	-	-	-	-	22	20
	23	6.0	5.5	5.0	4.5	4.0	3.5	-	-	-	-	-	23	
	24	7.0	6.5	6.0	5.5	5.0	4.5	-	-	-	-	-	24	
	25	8.0	7.5	7.0	6.5	6.0	5.5	-	-	-	-	-	25	
	26	9.0	8.5	8.0	7.5	7.0	6.5	-	-	-	-	-	26	
21	22	4.5	4.0	3.5	3.0	2.5	2.0	1.5	-	-	-	-	22	21
	23	5.5	5.0	4.5	4.0	3.5	3.0	2.5	-	-	-	-	23	
	24	6.5	6.0	5.5	5.0	4.5	4.0	3.5	-	-	-	-	24	
	25	7.5	7.0	6.5	6.0	5.5	5.0	4.5	-	-	-	-	25	
	26	8.5	8.0	7.5	7.0	6.5	6.0	5.5	-	-	-	-	26	
22	22	-	-	-	-	-	-	-	-	-	-	-	22	22
	23	5.0	4.5	4.0	3.5	3.5	2.5	2.0	1.5	-	-	-	23	
	24	6.0	5.5	5.0	4.5	4.5	3.5	3.0	2.5	-	-	-	24	
	25	7.0	6.5	6.0	5.5	5.5	4.5	4.0	3.5	-	-	-	25	
	26	8.0	7.5	7.0	6.5	6.5	5.5	5.0	4.5	-	-	-	26	
23	22	-	-	-	-	-	-	-	-	-	-	-	22	23
	23	-	-	-	-	-	-	-	-	-	-	-	23	
	24	5.5	5.0	4.5	4.0	4.0	3.0	2.5	2.0	1.5	-	-	24	
	25	6.5	6.0	5.5	5.0	5.0	4.0	3.5	3.0	2.5	-	-	25	
	26	7.5	7.0	6.5	6.0	6.0	5.0	4.5	4.0	3.5	-	-	26	
24	22	-	-	-	-	-	-	-	-	-	-	-	22	24
	23	-	-	-	-	-	-	-	-	-	-	-	23	
	24	-	-	-	-	-	-	-	-	-	-	-	24	
	25	6.0	5.5	5.0	4.5	4.5	3.5	3.0	2.5	2.0	1.5	-	25	
	26	7.0	6.5	6.0	5.5	5.5	4.5	4.0	3.5	3.0	2.5	-	26	
25	22	-	-	-	-	-	-	-	-	-	-	-	22	25
	23	-	-	-	-	-	-	-	-	-	-	-	23	
	24	-	-	-	-	-	-	-	-	-	-	-	24	
	25	-	-	-	-	-	-	-	-	-	-	-	25	
	26	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5	26	
t_{KRL} °C	t_i °C												t_i °C	t_{KRL} °C
t_{KVL} °C		14	15	16	17	18	19	20	21	22	23	24	t_{KVL} °C	

Testing hall, Airbus A380, IABG Dresden (D) (Photo Copyright IABG)

Heating performance with insulation

	Zehnder ZBN 300/2		Zehnder ZBN 450/3		Zehnder ZBN 600/4		Zehnder ZBN 750/5		Zehnder ZBN 900/6		Zehnder ZBN 1050/7		Zehnder ZBN 1200/8	
K	1.787	0.726	2.421	1.223	3.055	1.845	3.798	2.184	4.540	2.461	5.283	2.682	6.026	2.856
n	1.176	1.199	1.177	1.167	1.177	1.134	1.177	1.154	1.177	1.174	1.177	1.194	1.176	1.213
△t (K)	W/m	W/ Collector pair	W/m	W/ Collector pair	W/m	W/ Collector pair	W/m	W/ Collector pair	W/m	W/ Collector pair	W/m	W/ Collector pair	W/m	W/ Collector pair
120	498	226	677	326	856	420	1063	548	1270	678	1477	813	1683	952
118	488	222	663	320	839	413	1043	537	1245	665	1448	797	1650	933
116	479	217	650	313	823	405	1022	527	1221	652	1419	781	1617	914
114	469	213	637	307	806	397	1001	516	1196	639	1390	765	1584	895
112	459	208	624	301	789	389	980	506	1171	626	1361	749	1551	876
110	450	204	611	295	773	381	960	495	1147	612	1333	733	1519	857
108	440	199	598	288	756	373	939	485	1122	599	1304	717	1486	838
106	430	195	585	282	740	365	919	475	1098	586	1276	701	1454	819
104	421	191	572	276	723	358	899	464	1073	573	1248	686	1422	800
102	411	186	559	270	707	350	878	454	1049	560	1220	670	1390	782
100	402	182	546	264	691	342	858	444	1025	548	1191	654	1358	763
98	392	177	533	257	675	334	838	433	1001	535	1163	639	1326	745
96	383	173	520	251	658	326	818	423	977	522	1136	623	1294	726
94	374	169	508	245	642	319	798	413	953	509	1108	608	1262	708
92	364	164	495	239	626	311	778	403	929	497	1080	592	1231	690
90	355	160	482	233	610	303	758	393	905	484	1053	577	1199	671
88	346	156	470	227	594	296	738	383	882	471	1025	562	1168	653
86	337	152	457	221	578	288	718	373	858	459	998	546	1137	635
84	327	147	445	215	563	281	699	363	835	446	970	531	1106	618
82	318	143	432	209	547	273	679	353	811	434	943	516	1075	600
80	309	139	420	203	531	266	660	343	788	421	916	501	1044	582
78	300	135	408	197	516	258	640	333	765	409	889	486	1014	564
76	291	131	395	191	500	251	621	323	742	397	863	471	983	547
74	282	127	383	185	485	243	602	313	719	385	836	457	953	530
72	273	123	371	180	469	236	583	304	696	372	810	442	923	512
70	264	119	359	174	454	228	564	294	674	360	783	427	892	495
68	255	114	347	168	439	221	545	284	651	348	757	413	863	478
66	247	110	335	162	424	213	526	275	629	336	731	398	833	461
64	238	106	323	157	409	206	507	265	606	324	705	384	803	444
62	229	102	311	151	394	199	489	256	584	312	679	370	774	427
60	220	98.5	299	145	379	192	470	246	562	301	653	356	744	411
58	212	94.6	288	140	364	184	452	237	540	289	628	341	715	394
56	203	90.7	276	134	349	177	434	227	518	277	602	327	686	378
55	**199**	**88.7**	**270**	**131**	**342**	**174**	**425**	**223**	**507**	**271**	**590**	**320**	**672**	**369**
54	195	86.8	264	128	334	170	415	218	496	266	577	314	658	361
52	186	83.0	253	123	320	163	397	209	475	254	552	300	629	345
50	178	79.2	242	117	305	156	379	199	453	243	527	286	601	329
48	170	75.4	230	112	291	149	362	190	432	231	502	272	573	313
46	161	71.6	219	107	277	142	344	181	411	220	478	259	545	297
44	153	67.9	208	101	263	135	326	172	390	209	453	246	517	282
42	145	64.2	197	95.8	249	128	309	163	369	198	429	232	489	266
40	137	60.6	186	90.5	235	121	292	154	349	187	405	219	462	251
38	129	57.0	175	85.2	221	114	275	145	328	176	382	206	435	236
36	121	53.4	164	80.0	208	107	258	136	308	165	358	193	408	221
34	113	49.8	153	74.9	194	101	241	128	288	154	335	181	382	206
32	105	46.4	143	69.7	181	93.9	224	119	268	144	312	168	355	191
30	97.5	42.9	132	64.7	167	87.3	208	111	249	133	289	155	329	177
28	89.9	39.5	122	59.7	154	80.7	192	102	229	123	266	143	304	163
26	82.4	36.1	112	54.7	141	74.2	176	93.8	210	113	244	131	278	149
24	75.0	32.8	102	49.9	129	67.8	160	85.5	191	103	222	119	253	135
22	67.7	29.6	91.9	45.1	116	61.4	144	77.3	173	92.6	201	107	229	122
20	60.5	26.4	82.2	40.3	104	55.1	129	69.3	154	82.8	179	95.8	204	108

Heating and cooling performance
The following tables show the Zehnder ZBN heating and cooling performance in relation to the temperature difference. The values of the heating performance are measured according to EN 14037; the measurement results of the cooling performance are based on DIN 14240.

Please note: Removing the insulation has a positive effect on the cooling performance (see table). This additional performance can, however, only be attributed to the room if the panels are not fitted in a closed ceiling.

By removing the insulation, the heating performance does increase, but this results in a heat accumulation below the ceiling.

Perfomance
$= K \cdot \triangle t^n$

Cooling perfomance without insulation

	Zehnder ZBN 300/2	Zehnder ZBN 450/3	Zehnder ZBN 600/4	Zehnder ZBN 750/5	Zehnder ZBN 900/6	Zehnder ZBN 1050/7	Zehnder ZBN 1200/8
K	3.131	4.513	5.896	7.259	8.622	9.985	11.348
n	1.083	1.083	1.083	1.083	1.083	1.083	1.083
△t (K)	W/m	W/m	W/m	W/m	W/m	W/m	W/m
15	59	85	111	136	162	188	213
14	55	79	103	127	150	174	198
13	50	73	95	117	139	161	183
12	46	67	87	107	127	147	167
11	42	61	79	97	116	134	152
10	38	55	71	88	104	121	137
9	34	49	64	78	93	108	123
8	30	43	56	69	82	95	108
7	26	37	49	60	71	82	93
6	22	31	41	51	60	70	79
5	18	26	34	41	49	57	65

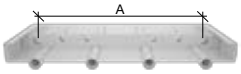
Cooling performance with insulation

	Zehnder ZBN 300/2	Zehnder ZBN 450/3	Zehnder ZBN 600/4	Zehnder ZBN 750/5	Zehnder ZBN 900/6	Zehnder ZBN 1050/7	Zehnder ZBN 1200/8
K	2.683	3.695	4.707	6.056	7.405	8.753	10.102
n	1.083	1.083	1.083	1.083	1.083	1.083	1.083
△t (K)	W/m	W/m	W/m	W/m	W/m	W/m	W/m
15	50	69	88	114	139	164	190
14	47	64	82	106	129	153	176
13	43	59	76	97	119	141	162
12	40	54	69	89	109	129	149
11	36	50	63	81	99	117	136
10	32	45	57	73	90	106	122
9	29	40	51	65	80	95	109
8	26	35	45	58	70	83	96
7	22	30	39	50	61	72	83
6	19	26	33	42	52	61	70
5	15	21	27	35	42	50	58

Museum „Dauphin Speed Event“, Offenhausen (D)

Technical Data at a glance

1) Higher operating temperatures available on request
2) Higher operating pressure available on request
3)



	Zehnder ZBN		Units	Panel model						
	Type			300/2	450/3	600/4	750/5	900/6	1050/7	1200/8
Dimensions	Widths		mm	300	450	600	750	900	1050	1200
	Number of tubes		no.	2	3	4	5	6	7	8
	Pipe material / size (Ø outside x tube thickness)		–/mm	Precision steel tube / 28 x 1.5						
	Panel material		–	Steel						
	Tube centres		mm	150						
	Length individual panel min.		mm	2000						
	Length individual panel max.		mm	7500						
	Suspension points per fixing bar		no.	2	2	2	2	2	2	2
	Distance of the fixing point centres (A)[3]		mm	200	350	500	650	800	950	1100
Parameter	Max. operating temperature[1]		°C	120						
	Max. operating pressure[2]		bar	10						
Weights	Dry weight excluding water content with insulation	Radiant panel	kg	6.95	9.67	12.42	15.14	17.86	22.08	24.83
		per collector pair	kg	1	1,5	2	2,5	3	3,5	4
	Operating weight with water content and insulation	Radiant panel	kg	7.94	11.14	14.38	17.59	20.8	25.52	28.76
		per collector pair	kg	1.5	2.2	3	3.7	4.5	5.2	6
	Weight of insulation		kg/m	0.3	0.45	0.6	0.75	0.9	1.05	1.2
	Weight of ball guard		kg/m	0.29	0.42	0.55	0.68	0.81	0.94	1.67
	Water content		kg/m	0.982	1.473	1.964	2.455	2.946	3.437	3.928
Heating output	Heat output according to EN 14037 at $\triangle t = 55K$ with insulation		W/m	199	270	342	425	507	590	672
	Constant of heating output		K	1.787	2.421	3.055	3.798	4.540	5.283	6.029
	Exponent of heating output		N	1.176	1.177	1.177	1.177	1.177	1.177	1.176
Cooling output	Cooling performance based on EN 14240 at $\triangle t = 10\,K$ with insulation		W/m	32	45	57	73	90	106	122
	Constant of cooling performance		K	2.683	3.695	4.707	6.056	7.405	8.753	10.102
	Exponent of cooling performance		N	1.083	1.083	1.083	1.083	1.083	1.083	1.083

Minimum mass flow rate

To maintain the performance given in the table, a turbulent flow must be ensured in the tubes within the panel. This minimum water flow depends on the lowest system temperature. In the case of heating, it corresponds to the return temperature. In the case of cooling and combined cooling/ heating, it corresponds to the cold water flow temperature. If the minimum water flow per tube is not reached, a reduction in performance of approximately 15 % can occur.

Limiting temperatures

In order to achieve optimal comfort levels of the radiant system, the correct design temperature must be selected. This can be checked on the basis of the following table and the diagram. The design temperature must then be less than the two limiting temperatures. In areas where people are present for only a short time, higher limiting temperatures are possible.

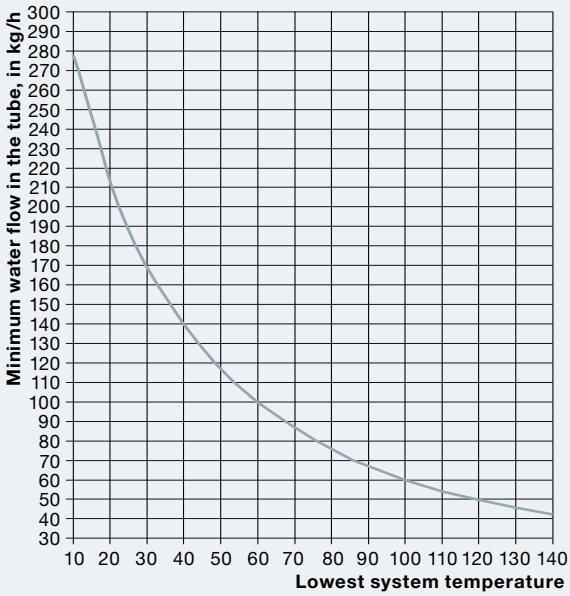
These are reference values.
A detailed calculation is possible according to ISO 7730.

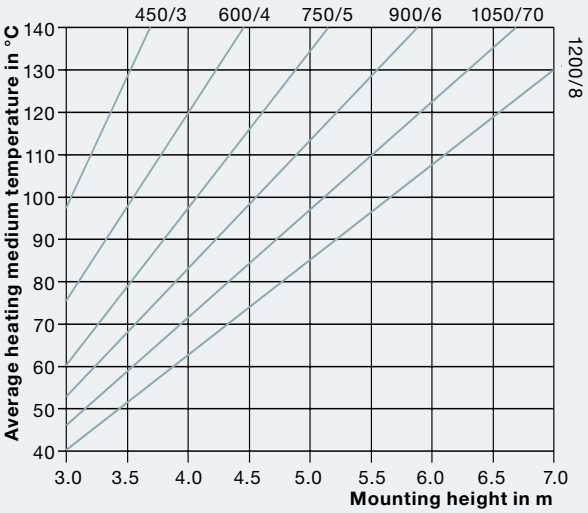
mounting height	Proportion of the ceiling surface covered by the radiant ceiling panels Zehnder ZBN					
m	at 10%	at 15%	at 20%	at 25%	at 30%	at 35%
	Average heating medium temperature in °C					
3	73	71	68	64	58	56
4	115	105	91	78	67	60
5	>147	123	100	83	71	64
6		132	104	87	75	69
7		137	108	91	80	74
8		>141	112	96	86	80
9			117	101	92	87
10			122	107	98	94

Step 1: Ceiling paneling. The design temperature must not exceed the defined limiting values.

Ball/ Projective safety

When used in sports halls, the stability of the radiant ceiling panels is particularly important, for example, when they are likely to be accidentally hit by balls. Therefore, Zehnder ZBN radiant ceiling panels are checked in accordance with DIN 18032, Part 3 with regard to ball throw safety. The testing was carried out by the Materials Testing Institute, Stuttgart.



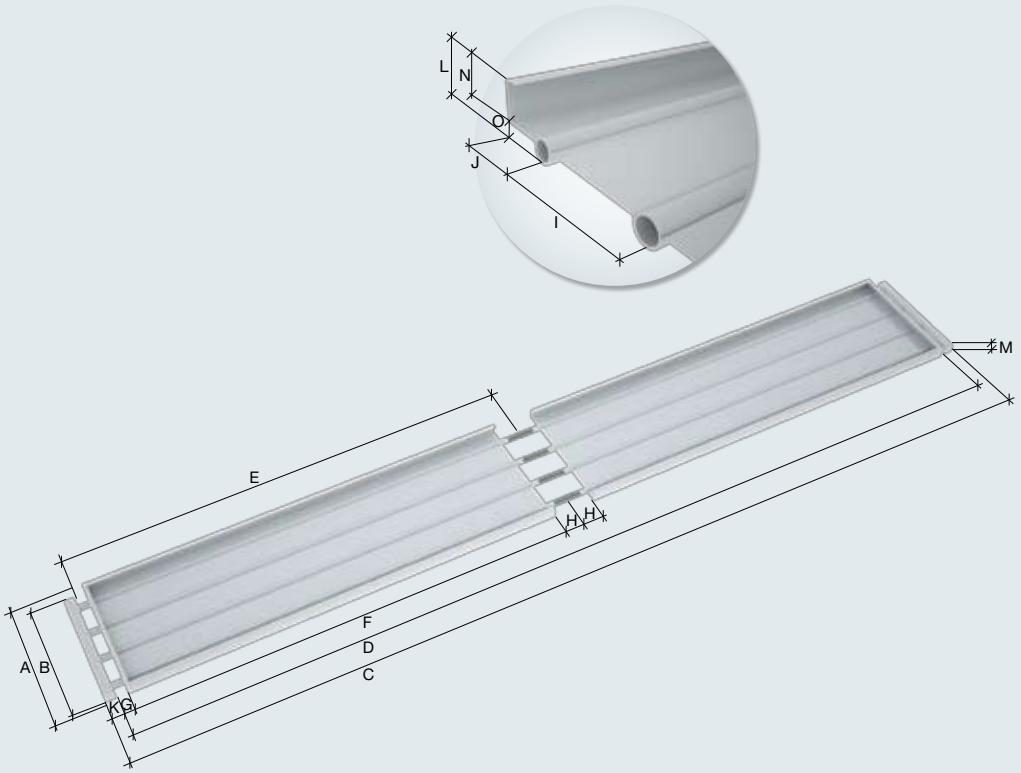


Step 2: Radiant panel width. The design temperature must not exceed the defined limiting values.

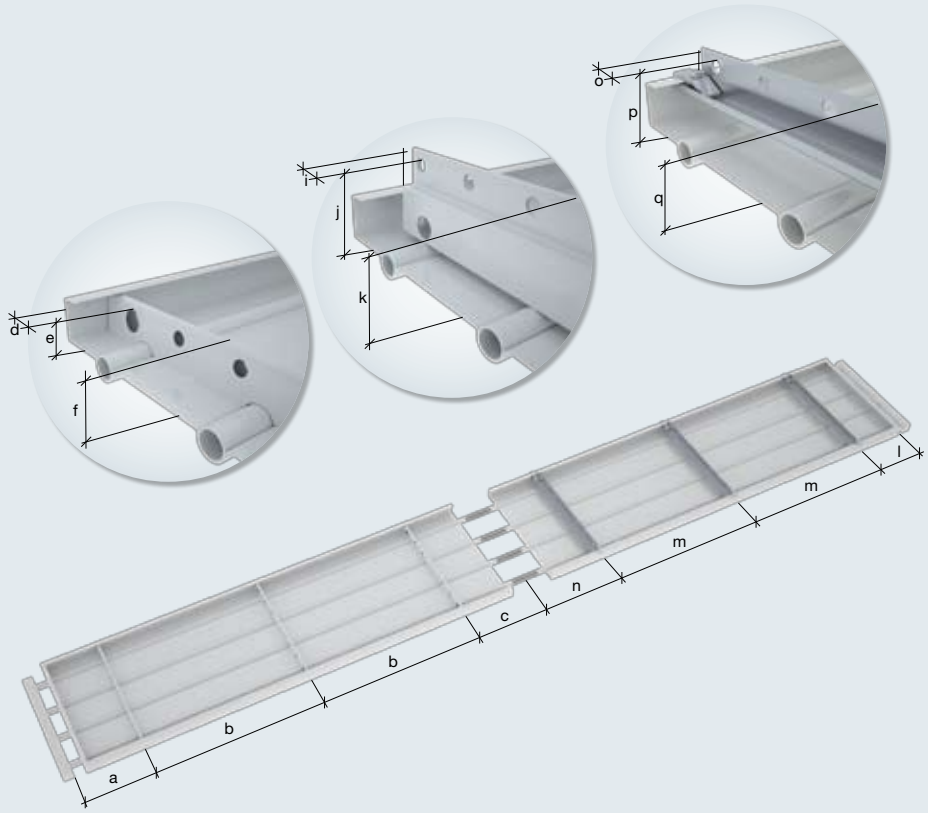
Multiplex sports hall, Munich (D)

Dimensions

Panel dimensions



Fixing dimensions



Panel dimensions

Pos.	Description	Size in mm	Min. size in mm	Max. size in mm	Remark
A	Total width	variable	300	1200	Grid width 150 mm
B	Width of header	variable	250	1150	Grid width 150 mm
C	Total length (excluding connections)	variable	2090	120 090	
D	Length of tubes	variable	2000	120 000	
E	Length of individual panel	variable	2000	7500	
F	Length of active panel	variable	1900	7400	
G	Tube projection to header	variable	50	2000	Standard 50 mm
H	Tube projection to the connecting piece	variable	100	2000	Standard 100 mm
I	Distance tube centres	150	–	–	
J	Distance tuber center – edge	75	–	–	
K	Length of header	45	–	–	
L	Total height (excluding suspension)	69	–	–	
M	Height of header	45	–	–	
N	Edge Height	50	–	–	
O	Depth of tube beading	19	–	–	

Fixing dimensions

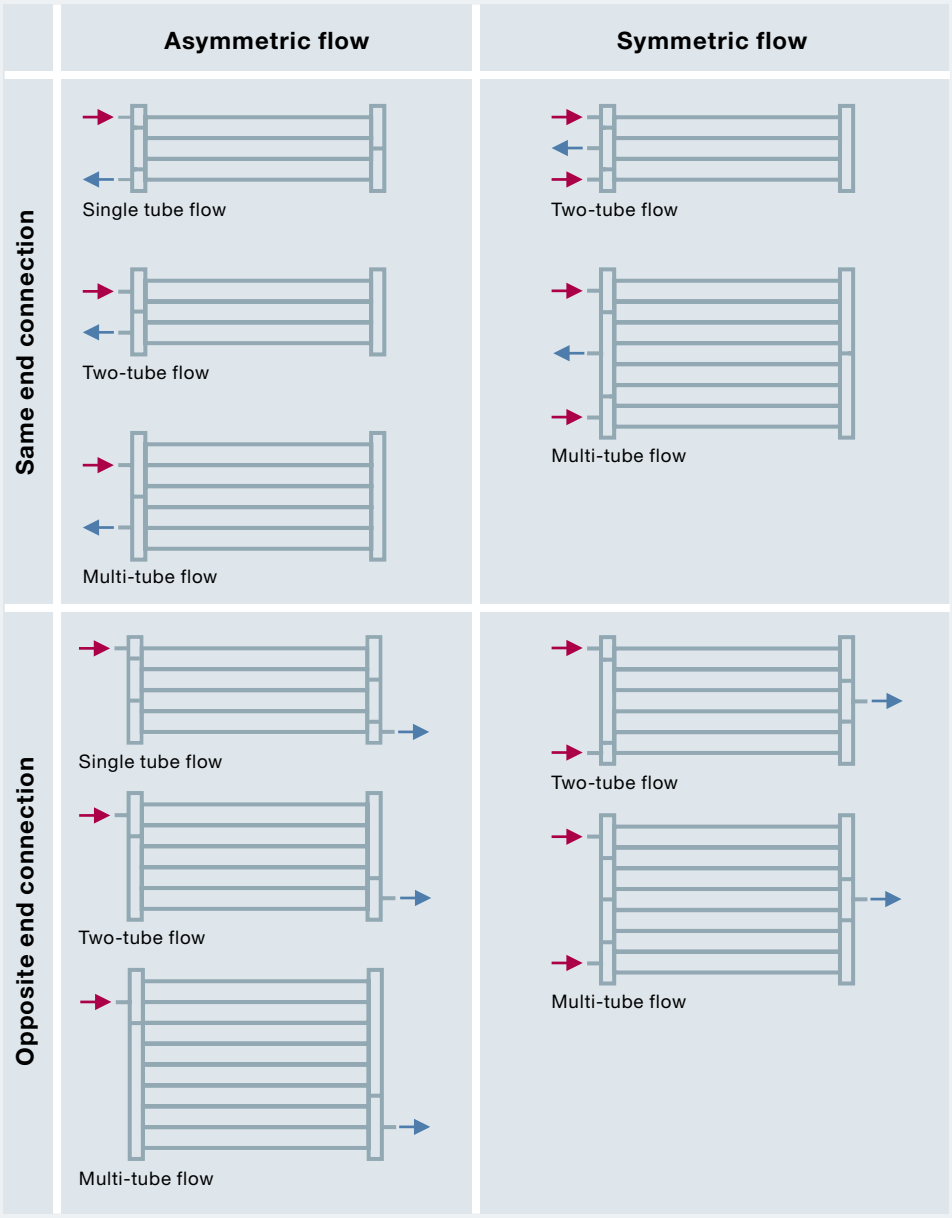
Pos	Description	Size in mm	Min. Size in mm	Max. Size in mm	Remark
Fixed suspension bars, panel type 300 – 900					
a	Header – middle of fixing bar	variable	50	1000	Standard size 500 mm
b	Fixing bar – Fixing bar	variable	50	3250	Standard size 3250 mm
c	Middle of fixing bar – connection junction	variable	100	3150	Standard size 800 mm
d	Outer panel edge – middle 1st suspension point	50	–	–	
e	Lower edge of radiant panel – upper edge of suspension point	39	–	–	
f	Lower edge of radiant panel – Upper edge of fixing bar	47	–	–	
Fixed suspension bars, panel type 1050 – 1200					
a	Header – middle of fixing bar	variable	50	1000	Standard size 500 mm
b	Fixing bar – Fixing bar	variable	50	3250	Standard size 3250 mm
c	Middle of fixing bar – connection junction	variable	100	3150	Standard size 800 mm
i	Outer panel edge – middle 1st suspension point	50	–	–	
j	Lower edge of radiant panel – upper edge of suspension point	92	–	–	
k	Lower edge of radiant panel – Upper edge of fixing bar	100	–	–	
Variable suspension bars, panel type 300 – 1200					
l	Header – middle of fixing bar (loose)	variable	90	750	
m	Fixing bar (loose) – Fixing bar (loose)	variable	60	3000	
n	Middle of fixing bar (loose) – connection junction	variable	190	2810	
o	Outer panel edge – middle 1st suspension point	50	–	–	
p	Lower edge of radiant panel – upper edge of suspension point	74	–	–	from width 1050; 77 mm
q	Header – middle of fixing bar	82	–	–	from width 1050; 94 mm

Flow configuration

Asymmetric and symmetric flow
In the case of freely suspended panel runs, an asymmetric water flow is possible. When installing in a suspended ceiling a symmetric flow pattern is recommended to ensure uniform expansion.

Same end and opposite end connections
Connections can be positioned to suit requirements for each installation.

Internal flow configuration
Panels are configured with internal divertors to ensure that the requirements for minimum (turbulent) flow are achieved.



Dinner printing plant, Schwanau (D)

Optimal heat distribution

Optimal distribution of radiant heat
Radiation in radiant ceiling panels takes place downwards into the room. Here, heat distribution in the room is dependent on the dimensions, temperature and layout of the panels. By using lower operating temperatures and larger panel heating surfaces than other systems which use extremly high operating temperatures from much smaller surfaces a very even heat distribution is achieved.

Layout when heating individual areas
If there is basic heating in a space, the temperature in individual areas can be raised through the use of radiant panels. If there is no basic heating present, it will not be possible to achieve comfort conditions in individual areas.

Optimal layout of the radiant panels
An even distribution of temperature is important for comfort in the room. It is therefore very important to position the radiant ceiling panels correctly.

Various layout possibilities (with equal temperatures for all radiant panels) and the effects of radiant intensity resulting from this are shown in Figs. 1-6. Here, Fig. 6 indicates the optimum in even distribution. The following principles can be deduced from this:

- Layout parallel to the longest outer wall, if necessary also on outer walls at the front.
- Distance from outer wall to the first run of radiant panels: approx. 0.5 – 2 m.
- Distance from centre to centre of the radiant panels is equal to the distance from floor to the radiant panel (suspension height).
- Outer runs of radiant panels parallel to the outer walls are wider, strips in the centre of the room should be narrower (outer wall compensation).
- Installed panel lengths should be as long as possible (reduction of investment costs).

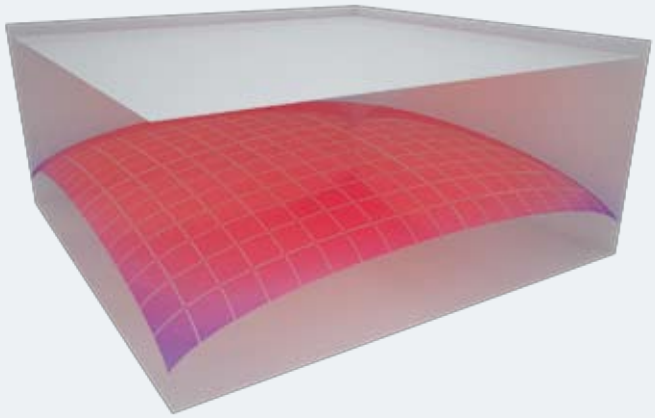


Fig. 1: Entire surface of ceiling is heated: uneven distribution of radiant intensity with maximum in the centre of the room.

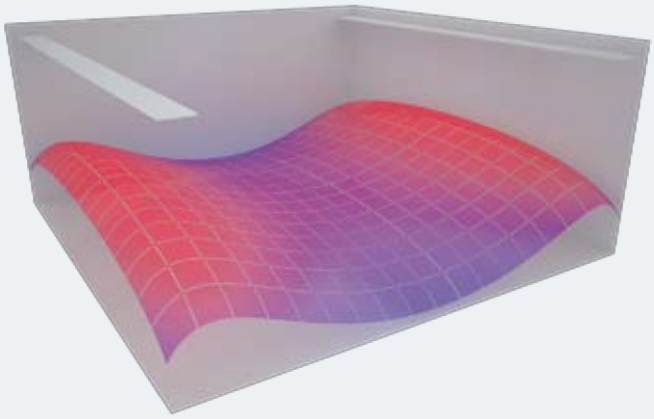


Fig. 2: Two equal radiant panels on the outer walls: very uneven distribution of the radiant intensity with maximum on the outer walls.

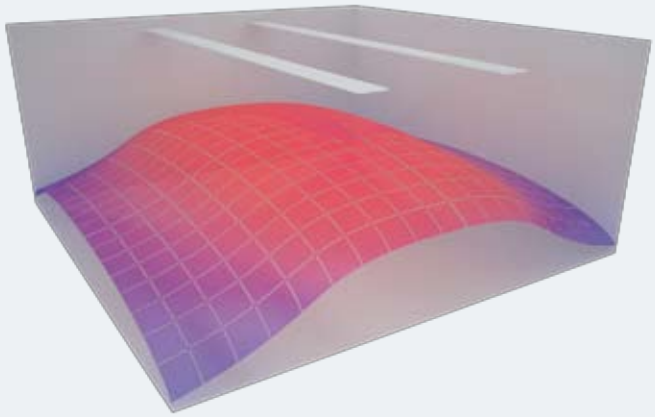


Fig. 3: Two equal radiant panels in the centre of the room: very uneven distribution of the radiant intensity with maximum in the centre of the room.

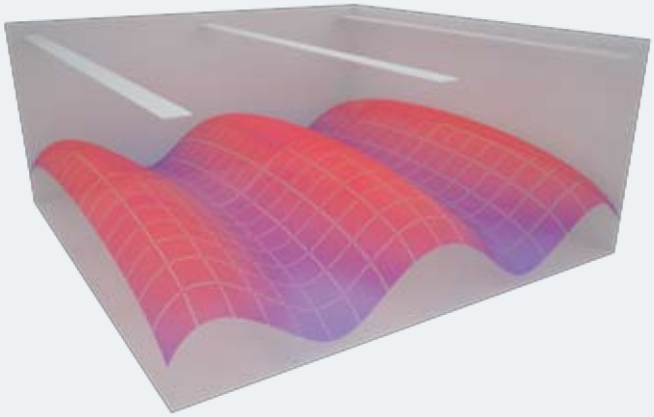


Fig. 4: Three equal radiant panels, two on the outer walls and one in the center of the room: uneven distribution of the radiant intensity with maximum in the centre of the room and on the outer walls.

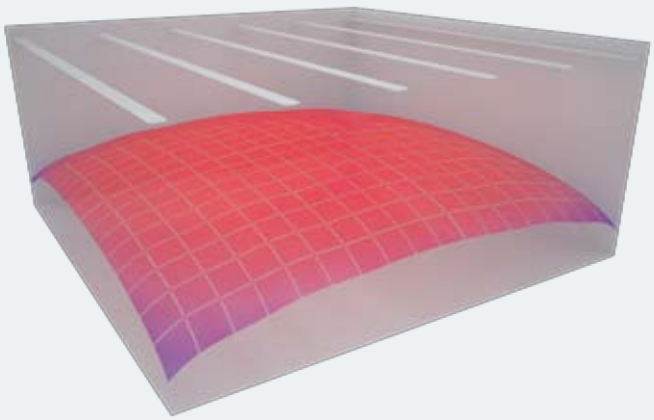


Fig. 5: Six equal radiant panels evenly distributed over the entire room surface: almost even distribution of the radiant intensity with a decrease at the outer walls.

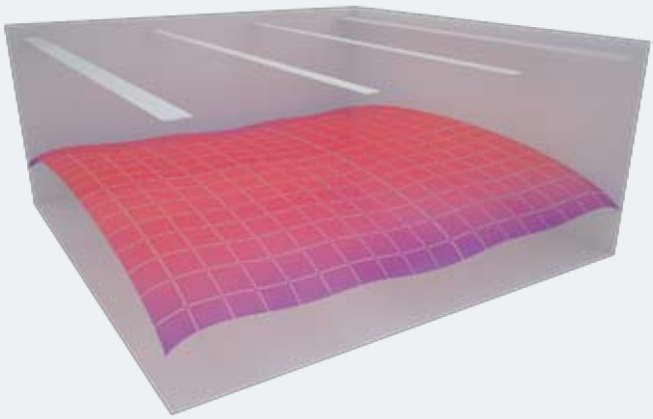


Fig. 6: Two wide radiant panels on the outer walls and two narrow panels in the centre of the room: optimal distribution of the radiant intensity over the entire surface of the room.

Design example

Basic design
The heating load of the room is calculated according to the applicable standard in each case. If the transmission heat loss of the ceiling is more than 30% of the total heating load, this indicates an increase in heat losses in the ceiling area. If better insulation of the ceiling is not considered, the upper heat insulation of the radiant ceiling panels can be removed. The increased transmission heat loss can therefore be covered. If the air change in a room is above the usual extent of ventilation of joints and grooves (max. 1/h), particularly in the case of extract units, the air that enters subsequently must be pre-heated. Intake of cold air at doors and entrances or in loading areas cannot be prevented by radiant heating alone. Here, aids such as strip curtains, hot-air curtains and similar devices must be provided.

Example of design and layout
The following example shows how the design of a hall takes place.

Objective
Constant and even inside temperature (20° C)

Specifications
Detached hall:
Length 100 m, width 30 m,
Height 8 m
Air change: 0,3 h^{-1}
Outside temperature: -12° C

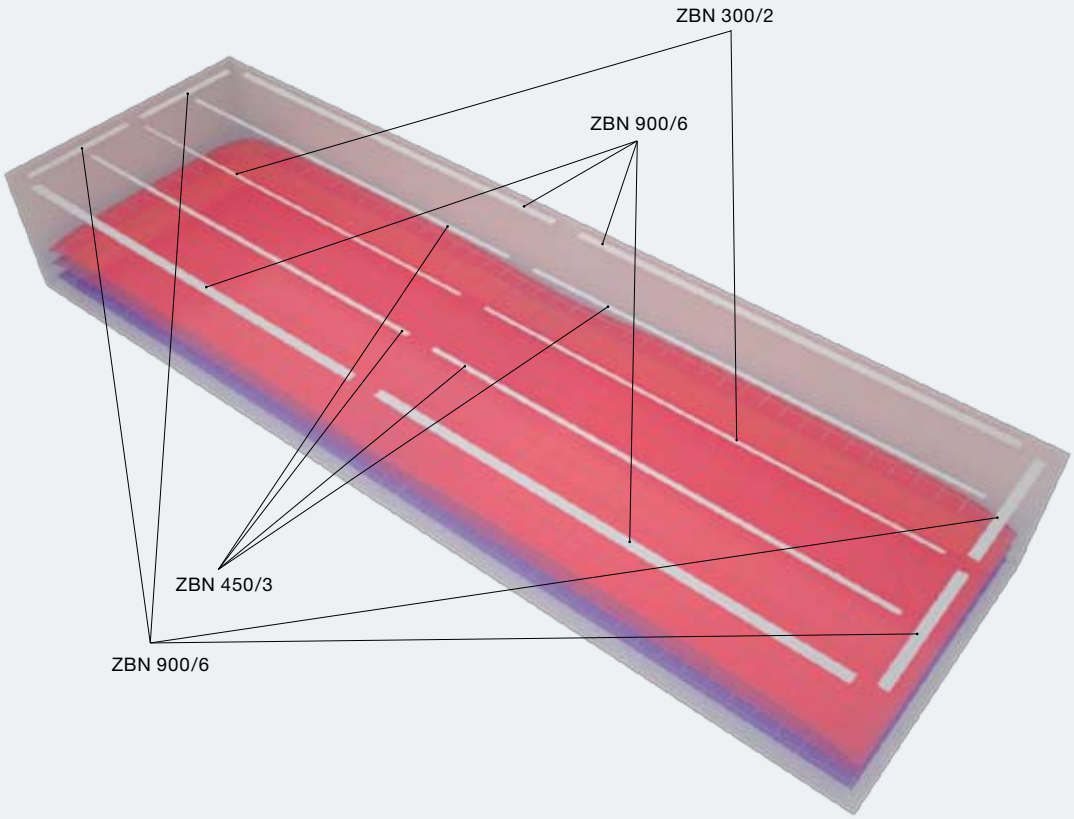
Heating load

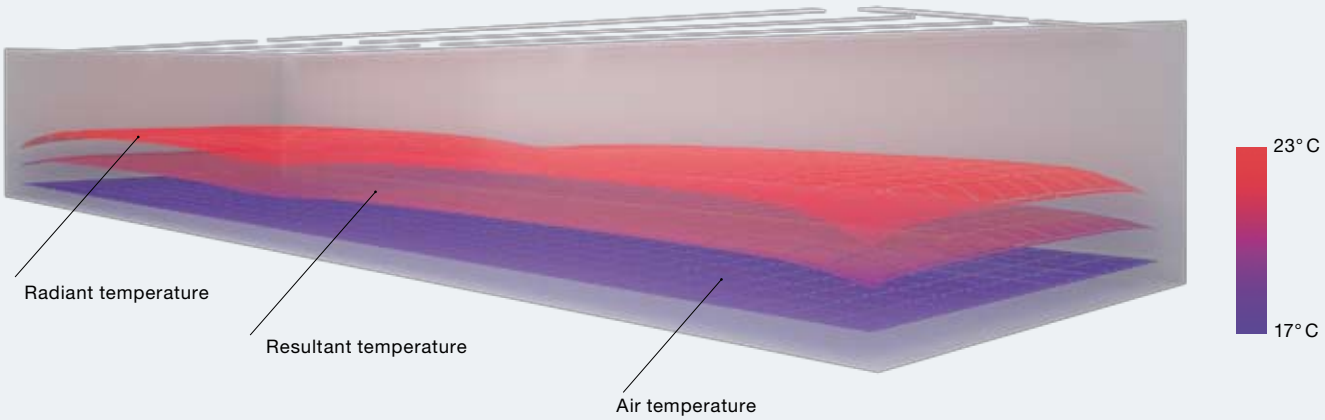
Standard transmission heat loss:	108500 W
Standard ventilation heat loss:	77260 W
Standard heat losses:	185760 W

Design of the radiant ceiling panels
Flow temperature: 80° C
Return temperature: 70° C

Type	Length m	Temperature difference K	Heat output W/m	Heat output W/Header pair	Number	Total heat output W
ZBN 900/6	12.5	55	507	271	4	26434
ZBN 900/6	45	55	507	271	4	92344
ZBN 450/3	45	55	270	131	4	49124
ZBN 300/2	45	55	199	88.7	2	18087
						185989

Layout
- 5 runs of radiant panels, arranged lengthwise, divided in the middle, equal distance from centre to centre 7.2 m, outer runs selected wider than the inner ones
- 1 run at each end, divided; distance between the runs and the outer walls: 1.5 m





Local distribution of the inside temperature is calculated for a height of 1 m above the floor in each case. The inside temperature also differs only slightly from the design value in the border areas.

Pressure loss calculation

The total pressure loss is made up of the pair of headers and the tubes.

Determining the pressure loss:

Example: ZBN 600/4; 20 m; Connection 1''

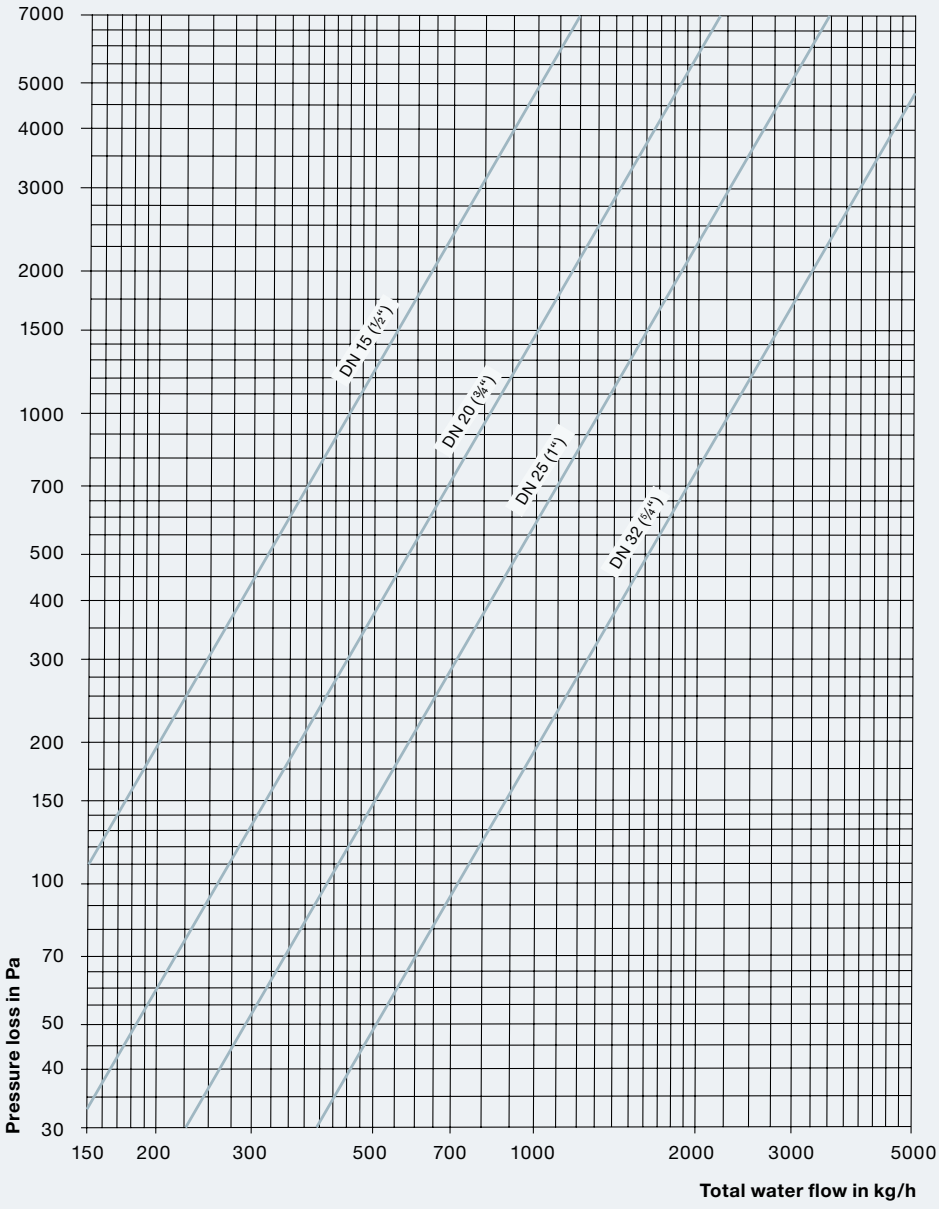
1. Determine the total mass flow of the radiant ceiling panel concerned.
   e.g. $\dot{m}$ = 600 kg/h

2. Read the pressure loss of the pair of headers from the diagram.
   e. g. $\triangle p_{hpair\ of\ headers}$ = 210 Pa/pair of headers at 600 kg/h and 1" pipe connection

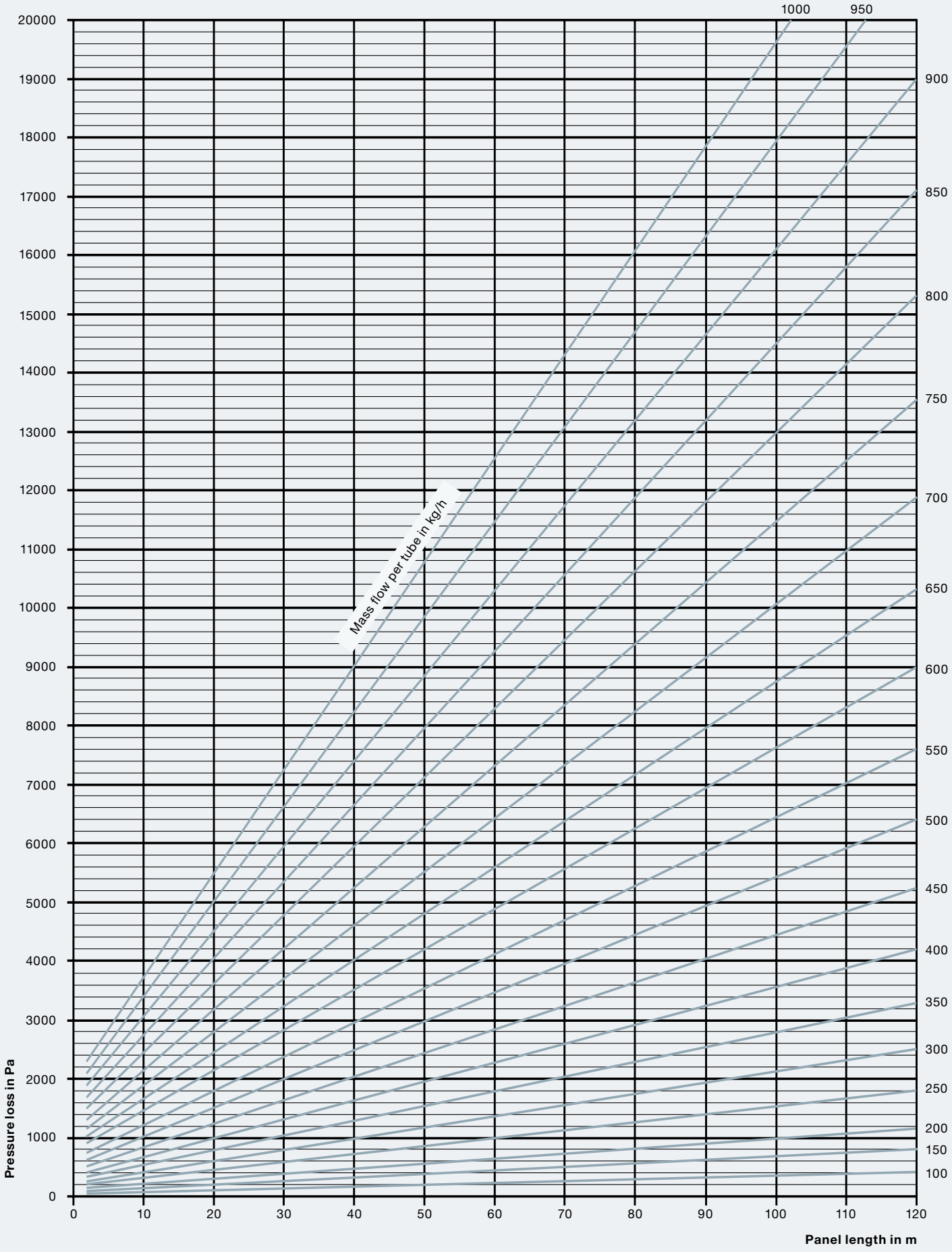
3. Obtain the pressure loss of the tube from the diagram. The mass flow is a result of dividing the total mass flow by the number of tubes flowing in parallel.
   e.g. 600 kg/h : 3 tubes series = 200 kg/h
   $\triangle p_{tube}$ = 300 Pa * 2 (each way) = 600 Pa

4. The total pressure loss of the radiant ceiling panel is now only to be seen as the sum of the individual pressure losses calculated beforehand,
   e.g. 210 Pa + 600 Pa = 810 Pa

Pressure loss, pair of headers



Pressure loss, tube



Flow balancing of radiant ceiling panels
Correct distribution of the heating water flow is important for the efficient operation of every branched heating and cooling system. (It should also be possible to fill, shut off and empty all runs of radiant ceiling panels separately).

In the case of units with identical radiant ceiling panels – and thus the same volume flow – the pipe layout based on the Tichelmann system (Fig. 1) represents an hydraulically flawless solution. However, the third pipe creates considerable costs particularly for large space heating systems and does not make sense in many cases due to the different sizes of the panels involved.

Units in which individual panels have different outputs must be balanced hydraulically by caculating all the systems pressure losses and adjusting accordingly. However, this is very time consuming and expensive.

Flow balancing is considerably simplified by the Zehnder volume flow regulator combination (VSRK) (Fig.2).

Fig. 1: Pipework layout according to the Tichelmann system

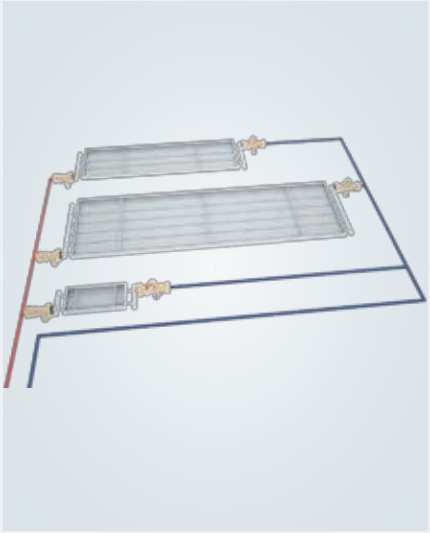


Fig. 2: Simpler pipework layout with Zehnder volume flow regulator combination (VSRK)

The Zehnder VSRK volume flow regulator combination
VSRK is a full set, consisting of a volume flow regulator, ball stop valves as well as filling and emptying ball valves. Headers of the radiant panels with suitable fittings can be made on request so that the VSRK can be installed directly.

The regulator (Fig.3) is pre-set at works to the volume flow of the run so that there will be no time consuming adjustment required on site.

Further advantages of the VSRK: Constant heating medium flow at higher differential pressure, flow balancing also for radiant panels of different sizes.

Volume flow (kg/h)	Total pressure loss (KPa)
120	15
125	19
130	15
135	18
145	16
155	19
180	19
190	19
205	17
230	17
235	19
275	19
290	17
300	16
325	17
340	17
355	17
365	16
400	16
405	19
410	16
415	18
465	19
475	19
505	19
530	19
535	20
540	19
595	21
625	21
640	21

Volume flow regulator combination VSRK DN-25

Volume flow (kg/h)	Total pressure loss (KPa)
600	15
820	23
830	16
950	16
1130	23
1220	16
1350	23
1360	17
1400	17
1520	24
1700	24
1710	17
1805	25
1930	18
2150	26
2240	19
2270	19
2300	26
2380	20
2420	20
2450	27
2740	21
2800	28
3000	29
3020	29
3060	23
3200	23
3250	31
3850	34
4200	36
4350	37

Volume flow regulator combination VSRK DN-32

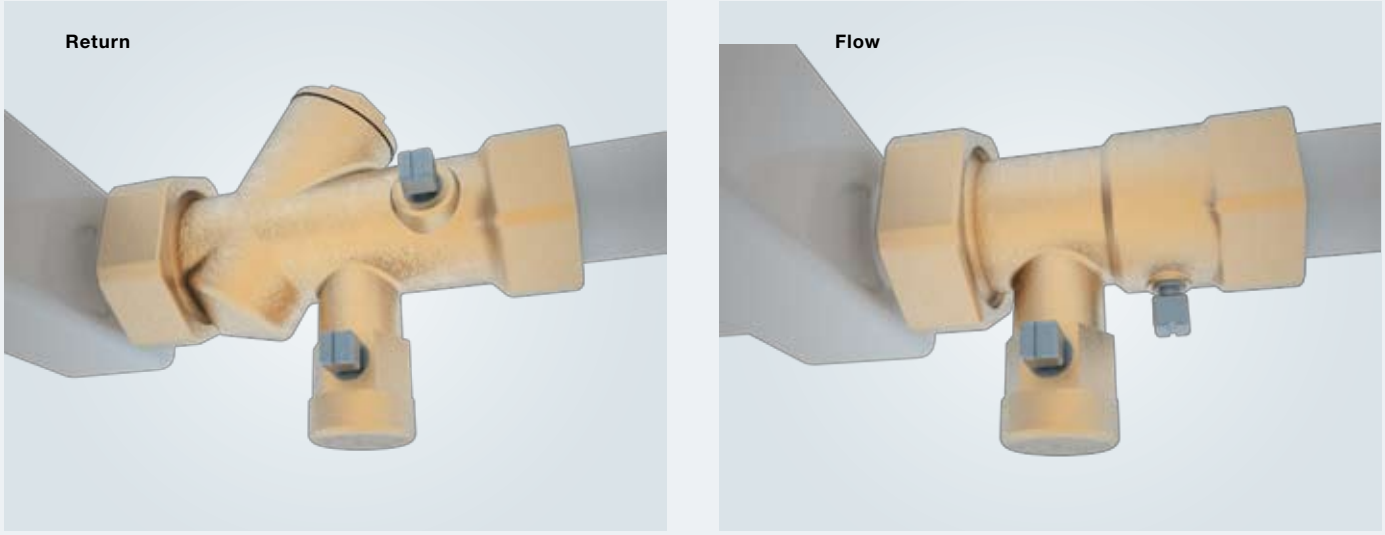


Fig. 3: Zehnder volume flow regulator combination. The dimensions depend on the selected welded tails.

Temperature control

Excess temperatures can be caused by the contribution of waste heat from machinery and production processes in large spaces which are heated by systems which are thermally inert or have large thermal mass.

This can be avoided by using Zehnder ZBN radiant ceiling panels as they can be regulated quickly and simply. This is because the system has low thermal mass and is very responsive.

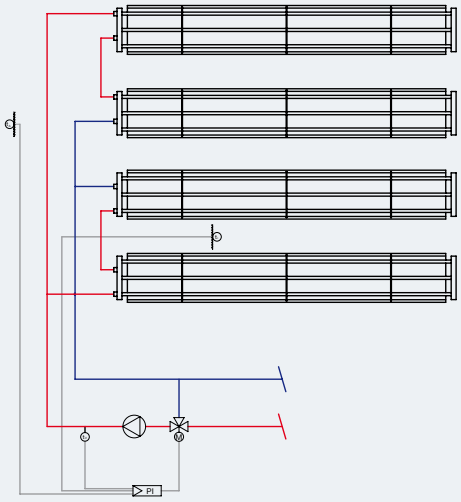
Zehnder radiant ceiling panels are therefore ideal for quickly changing thermal loads. This leads to savings in energy and costs and enhanced comfort conditions.

Globe sensor

The actual temperature experienced (resultant) by a person can be measured with the globe thermometer. This thermometer is particularly suitable when using radiant ceiling panels since it measures the radiant and air temperature equally. In the case of conventional thermometers that only measure air temperature, the desired value has to be adjusted at 2-3 Kelvin lower (heating).

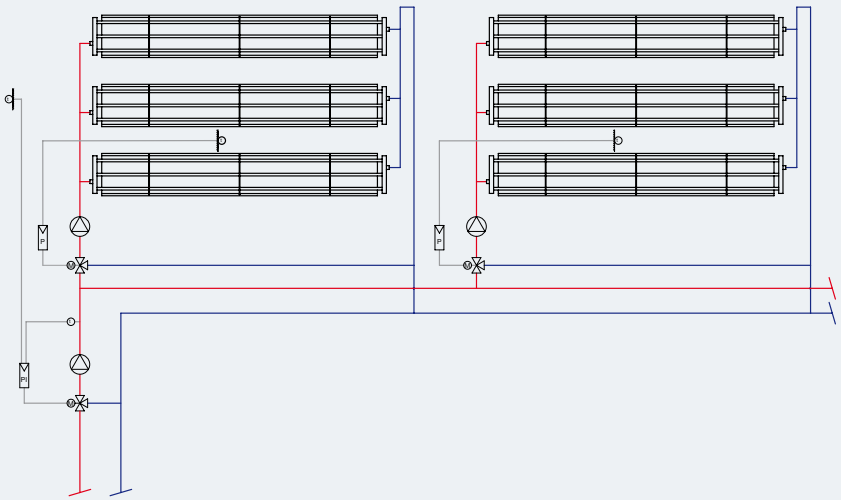
Globe thermometer

Controlling radiant panels



Flow temperature regulation with room compensation controlled by atmospheric conditions

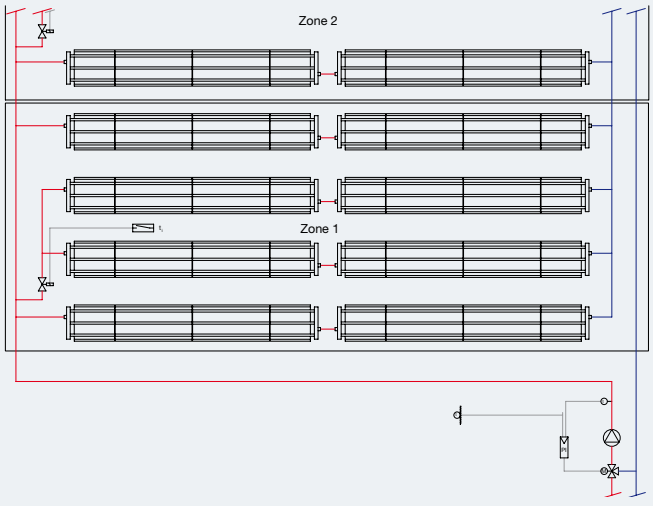
Equipment used:
- Flow sensor
- External sensor
- Room sensor
- Flow temperature regulation with room compensation controlled by atmospheric conditions
- Actuator



Flow temperature regulation with interconnection to room temperature as the command variable (if a flow temperature regulation controlled by atmospheric conditions already exists)

Equipment used, preliminary control:
- Flow sensor
- External sensor
- Flow temperature regulation controlled by atmospheric conditions
- Actuator

Room control:
- Room sensor
- Room regulator
- Actuator



Zone control for switching off individual radiant ceiling panels (if a flow temperature regulation controlled by atmospheric conditions already exists)

Equipment used, preliminary control:
- Flow sensor
- External sensor
- Flow temperature regulation controlled by atmospheric conditions
- Actuator

Room regulation:
- Room thermostat or electronic 2-point regulator
- Actuator

Zehnder ZBN specification text

Zehnder ZBN radiant ceiling panel, with waterways made of precision steel tubes according to DIN EN 10305-3, continuously welded to the radiant sheets using a patented double-spot welding process, through which the optimum thermal transfer is guaranteed. By profiling the radiant sheets for linear rigidity of the panel, distances of up to 3 m can be achieved between the welded suspension bars (variable bars on request). The radiant steel sheets are self-supporting through profiled side and top edges which also retain the insulation. The ends of the radiant sheets are closed by welded-on end plates. The headers are fitted with all necessary connections and internal diverters to ensure maximum heat output.

The quality as well as the heat output of the Zehnder radiant ceiling panels has been tested according to EN 14037-1 to -3. The operating pressure is max. 10 bar (higher pressure values on request). Operating temperature max. 120 °C (higher temperatures on request).

Brand: Zehnder
Type: Zehnder ZBN

- Powder coated to standard white RAL 9016
- Powder coated to a selected RAL colour
- Factory fitted insulation
- Optional perforated radiant panel sheet
- Optional with superimposed headers and endcover plates (delivered loose)
- Optional with plastic foil packaging
- Optional with dust protection top cover plate made of galvanized steel sheets
- Optional galvanized ball guards (delivered loose)
- Optional with press fittings 28 mm

Assembly kit type K 33
consisting of:
1 turnbuckle with 2 eyelets
1 chain 4 mm, length 500 mm (wire coils cut to length on site)
3 spring hooks
1 eyebolt
1 steel dowel
1 hexagonal nut

Assembly kit type K 34
consisting of:
1 turnbuckle with 2 eyelets
1 chain 4 mm, length 500 mm (wire coils cut to length on site)
3 spring hooks
1 eyebolt
2 hexagonal nuts

Assembly kit type K 36
consisting of:
1 turnbuckle with 2 eyelets
1 chain 4 mm, length 500 mm (wire coils cut to length on site)
3 spring hooks
1 eyebolt
1 hexagonal nut
1 trapezoid hanger bracket

Assembly kit type K 37
consisting of:
1 turnbuckle with 2 eyelets
1 chain 4 mm, length 500 mm (wire coils cut to length on site)
3 spring hooks
1 eyebolt
1 hexagonal nut
1 flat leaf bolt
1 screw
1 girder clamp
1 safety clip

Assembly kit type K 38
consisting of:
1 turnbuckle with 2 eyelets
1 chain 4 mm, length 500 mm (wire coils cut to length on site)
3 spring hooks
1 eyebolt
1 washer
1 hexagonal nut
1 girder clamp
1 safety clip

All individual parts of the assembly kits are galvanized.

VSRK-25
Zehnder volume flow regulator combination for flow and return, PN 12, up to 100 °C, max differential pressure 1.5 bar, with internal thread DN 25, consisting of:

1 insert for control with internal, directly regulating membrane regulator, ex-works adjusted to the heating medium flow
2 ball valves
2 filling/emptying ball valves

Volume flow regulator combination DN 25, Zehnder type: VSRK-25

When using VSRK the corresponding attached fittings can be welded on to the headers ex-works.

VSRK-32
Zehnder volume flow regulator combination for flow and return, PN 12, up to 100 °C, max. differential pressure 1.5 bar, with internal thread DN 32, consisting of:

1 insert for control with internal, directly regulating membrane regulator ex-works adjusted to the heating medium flow
2 ball valves
2 filling/emptying ball valves

Volume flow regulator combination DN 32, Zehnder type: VSRK-32

When using VSRK the corresponding attached fittings can be welded on to the headers ex-works.

Zehnder armoured flexible hoses
For heating systems consisting of temperature and ageing resistant EPDM with interwoven high grade steel casing.

Tube DN25
Length 500 mm
Permissible operating pressure: 10 bar
Permissible operating temperature: 90 °C
Attachments: 1st side AG 1“
2nd side IG 1 ¼“
Type PE 25/500

Zehnder armoured flexible hoses
For heating systems consisting of temperature and ageing resistant EPDM with interwoven high grade steel casing.

Tube DN32
Length 500 mm
Permissible operating pressure: 10 bar
Permissible operating temperature: 90 °C
Attachments: 1st side AG 1“
2nd side IG 1 ½“
Type PE 32/500

Heating – Cooling – Fresh Air
Energy saving system solutions with design

Competence comes with experience, and with over 100 years in producing radiators and over 40 years in ventilation experience, Zehnder is a leading European Manufacturer. With a comprehensive portfolio of heating, cooling and fresh air products supported by a committed, innovative company which sets and maintains very high standards, there can be no better choice, whatever your requirements.

Radiators for bathrooms and living rooms

Quality comes first for Zehnder. All goods supplied are subjected to strict quality control from design, material selection and production through to final checking to ensure that you, our customer, receive only the best possible product.

Systems for radiant heating and cooling

References are essential to give assurance of the competence and quality of the company you choose to work with: Zehnder has supplied products to just about every type of construction project throughout the world, from single family domestic residences to large office blocks, hospitals, sports facilities, storage depots and factories.

Comfosystems for fresh room air

Service for Zehnder means support at every stage of your project. From design and planning, through tendering, ordering, delivery, installation and commissioning, we are available to help.

Advice in the planning and construction phase

Systems for Radiant Heating and Cooling

Zehnder ZIP

Zehnder COMO

Zehnder COS

Flatline

Designer radiators

Radiators

Systems for room ventilation

Comfosystems