White Paper

The Basic Principles of Climate Ceilings – Technology/Applications/Benefits

Tailor-made solutions for indoor climate

BARCOL-AIR by Swegon

White Paper

The Basic Principles of Climate Ceilings – Technology/Applications/Benefits

Over recent decades, climate ceilings have become a standard solution for room cooling. These water based multifunctional systems, also known as radiant ceilings, can be found in office buildings and salesrooms, as well as in factory buildings and healthcare facilities.

Their functions are many and varied, and technological advances are leading to new insights and areas of application. This White Paper aims to explain the basic principles of radiant ceilings and in particular to provide an introduction to the practical implementation of radiant ceiling projects to support new technical designers.

The White Paper addresses the following questions:

- How does radiant cooling/heating work?
- What different kinds of ceiling system are used?
- What are the typical parameters of room air conditioning?
- What other ways are there of influencing indoor climate with radiant ceilings?

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Introduction

To perform to the best of our abilities at the office, it's important that the environment that we are in feels comfortable. Consequently, it's in the interest of all businesses to give their employees the perfect workspace in terms of room comfort. This is about more than just the temperature and air in the room, but also about the acoustic and visual experience, as well as the suitable lighting. At the same time, the requirements with regard to operation and energy efficiency are becoming ever more stringent – a system needs to be able to last for decades without any major maintenance work and with the lowest possible energy consumption.

All of these factors can be perfectly harmonised with a radiant ceiling, which explains why this system has gained ground over other room air conditioning options in recent years.

Contents

The general structure of radiant ceilings

In contrast to concrete core activation or flush mounted cooling systems, radiant ceilings are installed in a suspended ceiling.

In the case of metal radiant ceilings, the suspended ceiling comprises 0.7 to 1.0 mm thick steel or aluminium panels which, for acoustic and visual reasons, tend to be perforated. These panels are usually powder coated to protect the material and improve the emission of radiant heat (see page 5).

A thin acoustic fleece is often attached to the ceiling panel, to which the system used to convey the cooling medium is then attached.

This medium, generally water, is in most cases conveyed through copper tubes. These may be more expensive than plastic or stainless steel tubes, but they are much less susceptible to corrosion. In addition, the thermal conductivity of copper is ten times that of stainless steel, and one hundred times that of plastic.

The energy is distributed from the tubes to the ceiling panels through heat conducting rails (see page 6).

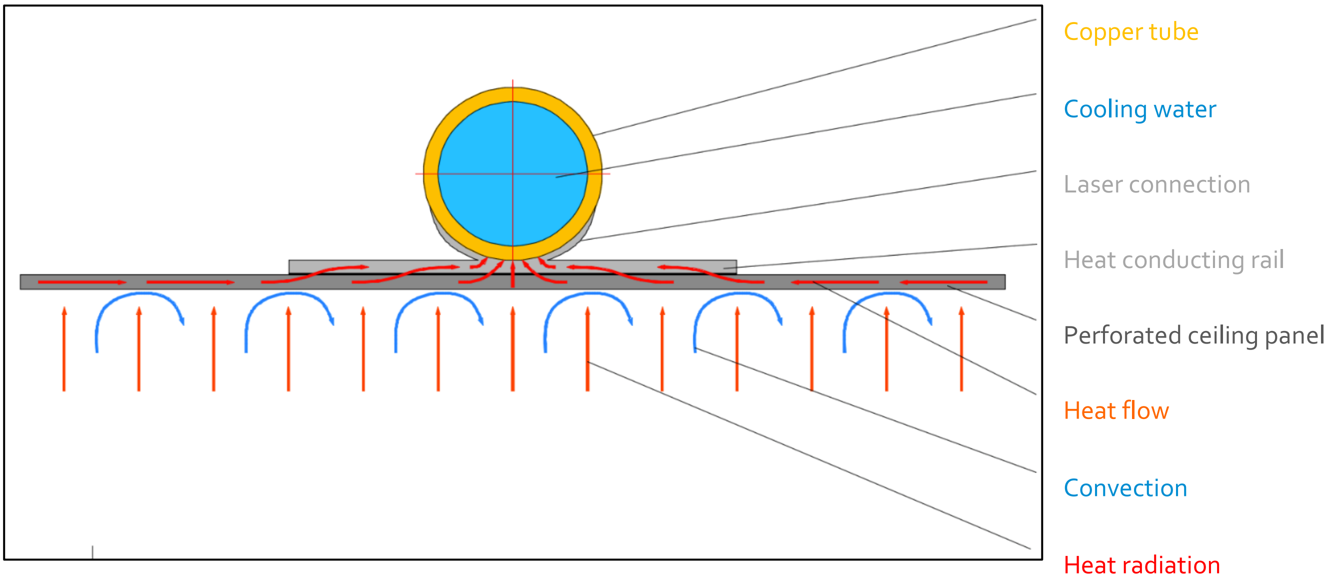


Fig. 1: Basic operating principle of a radiant ceiling

Suspended ceiling material

In addition to metal ceiling panels, plasterboard (gypsum) is a common material for suspended ceilings. When used for radiant ceilings, it should be at least highly compressed, ideally with integrated graphite. Other materials are expanded glass granulate panels, aluminium honeycomb panels etc.

Cooling and heating through radiation

The principal reason for the success of radiant ceilings is their heat exchange concept. Only around 40 to 50 % of cooling is achieved through direct cooling of the room air – the room, and the people in it, are cooled (or heated in the winter) primarily via thermal radiation. This has benefits:

- In contrast to cold air, heat radiation does not cause convection currents, which means there is no risk of draughts.
- People do not like (cold) moving air, but cooling by means of thermal radiation feels very pleasant.

Imagine being on the beach on a summer evening – the air is still warm, even though the air radiating from the sky is cool:

Fig. 2: As the night sky radiates cool air, the temperature is perceived as cooler than it actually is

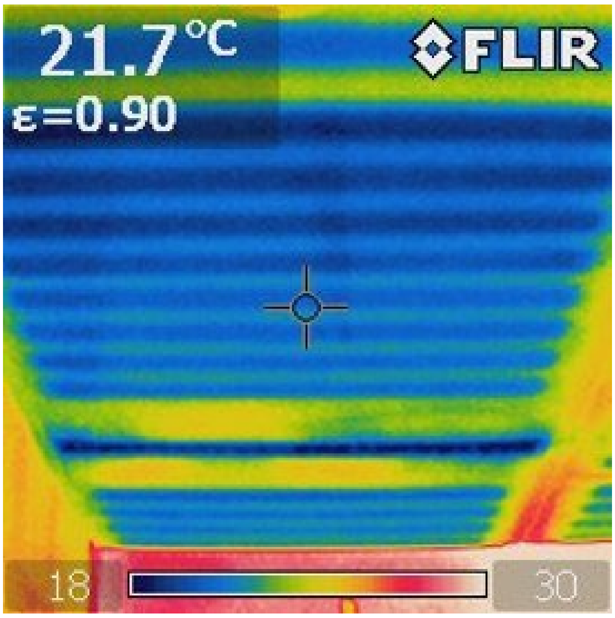


Fig. 3: Infrared image of a radiant ceiling in cooling operation

- As the ceiling is cool, the room itself feels cooler than it actually is. Consequently, the room does not need to be cooled as much for it to feel comfortable.
- In principle, thermal radiation is infinite (much like the heat from the sun), unlike cool air, which eventually gets conveyed away as extract air.

Heat conducting rail

The heat conducting rail distributes the energy from the copper tube over a larger area of the metal ceiling panel. There are a number of designs of rail, with aluminium the preferred material (heat conduction of aluminium: 200 W/m*K, steel 40 W/m*K and plastic 0.4 W/m*K).

Three commercially available versions of heat conducting rails with copper tube and aluminium:

- Extruded profile with copper tube frame
- Omega profile
- Welded profile

Version comparison

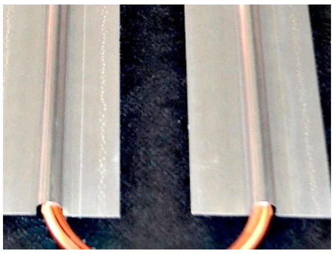
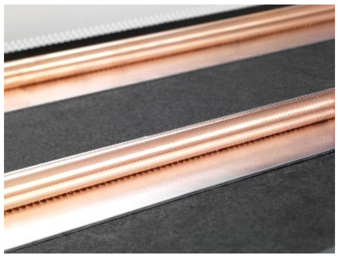
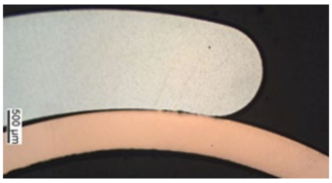
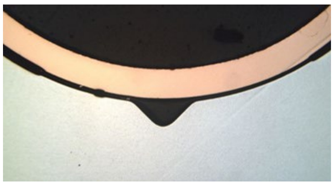
Versions	Extruded profile[1] with copper tube frame	Omega profile	Welded profile
Diagram			
Pipe – rail connection	- (micro air gap) 	- (micro air gap) 	++ (material closure) 
Cross line	+ (high material thickness)	- (thin panel)	- (thin panel)
Material requirement	-- (very high)	+ (low)	+ (low)

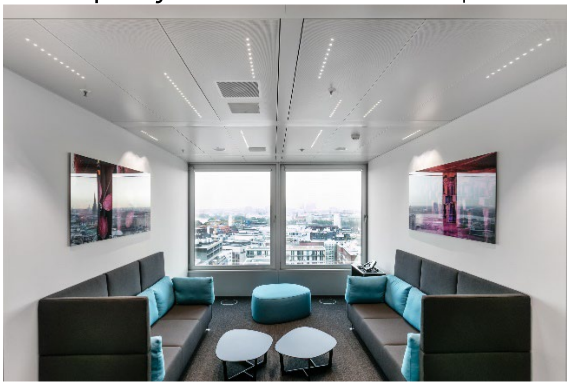
Fig. 4: Overview of heat conducting rail versions (images: © Barcol-Air and Ostschweizer Fachhochschule OST).
Key to symbols: ++ very good, + good, - poor, -- very poor

[1] The magnetic profile is a special type of extruded profile. It is not glued into the panels, but held in place in (steel) ceiling panels by magnetic tape. This considerably reduces the transport volume and is ideal for retrofitting existing ceilings.

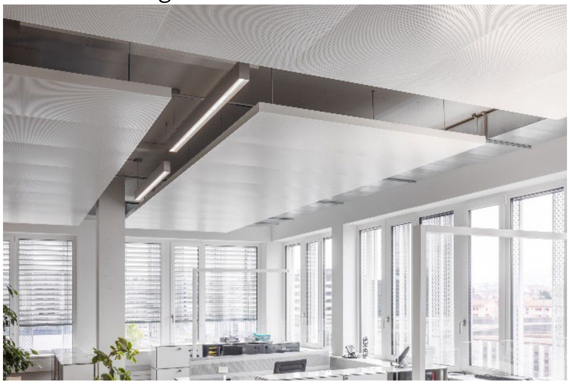
Ceiling systems

In addition to the functional requirements of a radiant ceiling, architectural preferences and trends have increasingly begun to influence designs over the last few years.

In the early 2000s, the **closed metal ceiling** was very much the norm, while today, **radiant sails and modules** as well as **open systems** are more commonplace, with the concrete ceiling still visible.

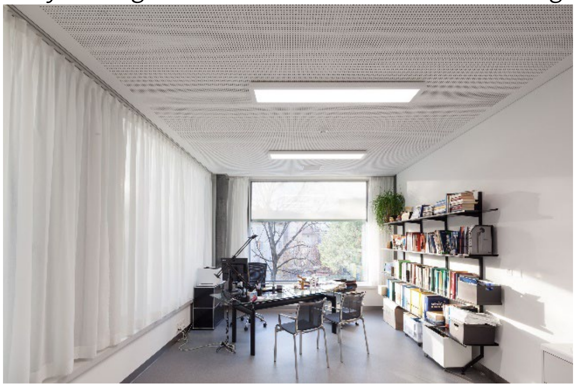


Closed metal ceiling (bandraster)



Sail

For those who do not want a metallic look, a **seamless plastered ceiling system** is an alternative option which is barely distinguishable from a conventional ceiling.

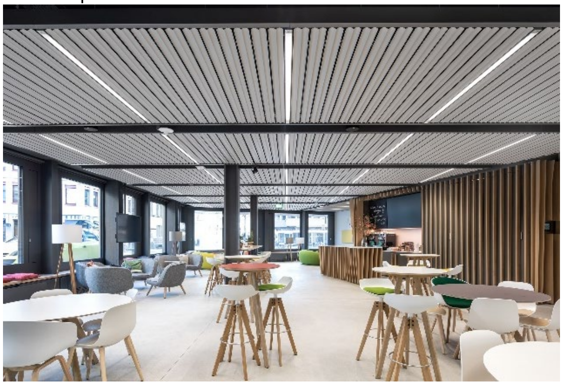


Perforated plasterboard panels

Unperforated plasterboard panels

Open ceiling systems comprise e.g. baffles or slats in different shapes and materials.

Baffles



Slats

Typical parameters for room air conditioning

Summer	Winter
Cooling load Must be determined on a project specific basis by a specialist design firm. Loads between 40 and 60 W/m² are realistic (in mid latitudes).	**Heating load** Must be determined on a project specific basis by a specialist design firm. Loads of approx. 25 W/m² are realistic (in the case of modern buildings).
Room temperature No impairment of people's performance is anticipated up to a perceived temperature of 26 °C. It is important to note that a room temperate of 26 °C will feel much cooler with a radiant ceiling.	**Room temperature** Usually 21 °C. In France, for example, the standard is 19 °C, which saves considerable amounts of energy.
Water flow temperature Generally speaking, surface heating/cooling systems can be operated with water flow temperatures that are close to room temperature, which saves a great deal of energy. Where previously 14 °C to 16 °C was common (risk of falling below dew point), technically optimised radiant ceilings can achieve flow temperatures of 18 °C or 19 °C. For much of the year, the building can be cooled with 'free cooling', i.e. without the cooler needing to be on, or its electrical consumption. This involves incorporating the building mass into the room air conditioning. (Recommendation: White Paper 'Radiant Ceilings with Mass Connection')	**Water flow temperature** The low heating loads mean that flow temperatures of approx. 32 °C are usually sufficient. People don't generally like their head being too warm. Flow temperatures over 35 °C are therefore not recommended.
Cooling performance (steel ceiling panels, approx. 8 K undertemperature) Radiant ceiling: approx. 70 - 80 W/m² Radiant sail: approx. 80 - 100 W/m²	**Heating performance (steel ceiling panels, approx. 10 K overtemperature)** Radiant ceiling: approx. 70 - 80 W/m² Radiant sail: approx. 80 - 100 W/m²

Pressure loss

The pressure loss is dependent on the spread between the flow and return temperatures (usually 2 - 3 K). It must not exceed 25 kPa in a water circuit.

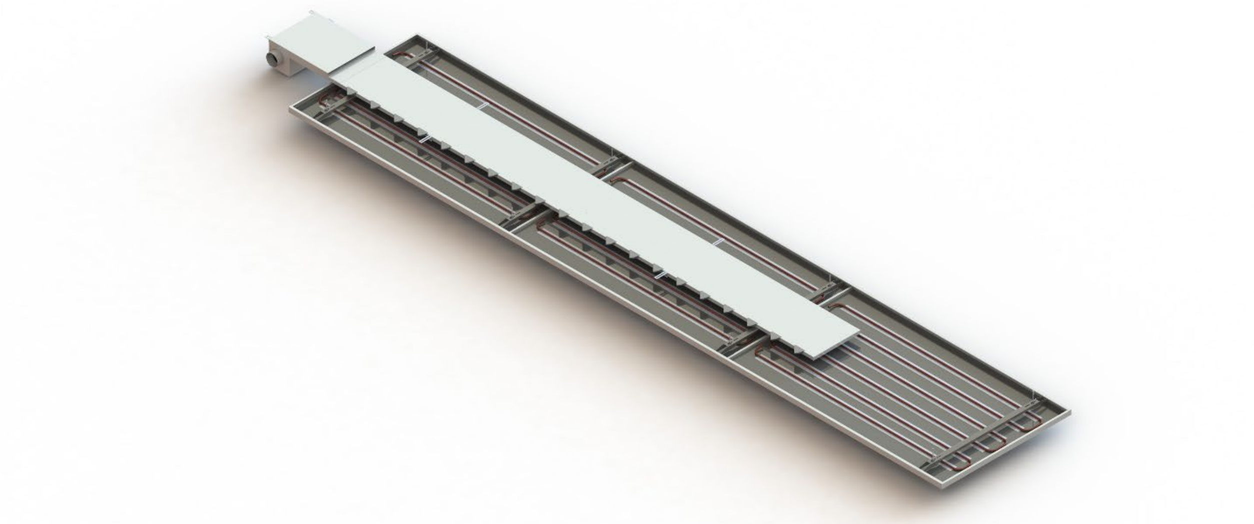
Supply air diffusers

Suspended ceilings are ideal for the installation of supply and extract air diffusers and for concealing the ducts that come with them. Air can be distributed effectively from the ceiling and into the room, as there are no requirements for room air speed in this area. Consequently, the air can be widely distributed on the ceiling at high speed before it descends into the occupied part of the room.

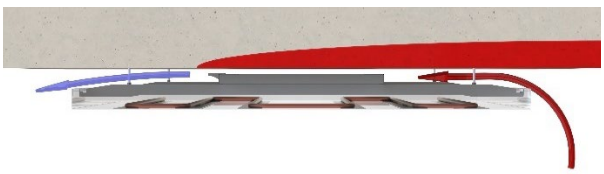
The efficiency requirements for room air conditioning have become more stringent in recent years. The building mass (concrete, brick) plays a particularly important role. If energy that does not need to be conveyed away immediately is stored in this mass throughout the day, it can be recovered from the mass at night when the outdoor temperatures have fallen.

(Recommendation: White Paper 'Radiant Ceilings with Mass Connection' and White Paper 'Increasing the Water Flow Temperature – Energy Efficient Cooling')

Consequently, the latest generation of supply air diffusers from Barcol-Air has been designed to feed warm room air into the concrete (building mass) throughout the day, thereby warming the mass so that the energy can then be recovered at night.



Day: The air flow (which is a hygiene requirement) is expelled through the high capacity induction nozzles. This causes induction of warm room air from behind the sail. Part of the energy is conveyed away immediately, while another part heats the concrete. The room temperature remains comfortable at all times.



Night: No supply air is required in the building overnight. The water can be cooled by means of free cooling (without the cooler). The exchange of radiation between the warm concrete and the cold heat conducting rails recovers the energy from the concrete and prepares it for the absorption of excess energy on the following day.

Fig. 5: Function of the Barcol-Air nozzle channel

Sound absorption

In addition to room temperature and room air, the acoustic experience also has a major impact on people's feeling of comfort in the workplace.

Building acoustics is a broad field related to this context. From sound absorption and sound insulation of ceilings to sound damping and the sound performance of supply air diffusers, Barcol-Air has worked with an accredited testing facility in Switzerland to undertake wide-ranging tests. Sound absorption remains the most important subject of research.

Ceilings are the largest free area in a room, which means that they are ideal for absorbing sound from conversations, printers, telephones, etc. With over 200 similar measurements in diverse configurations, it's possible to draw conclusions about sound absorption in virtually every conceivable ceiling design.

(Recommendation: White Paper 'Room Acoustic in Offices')

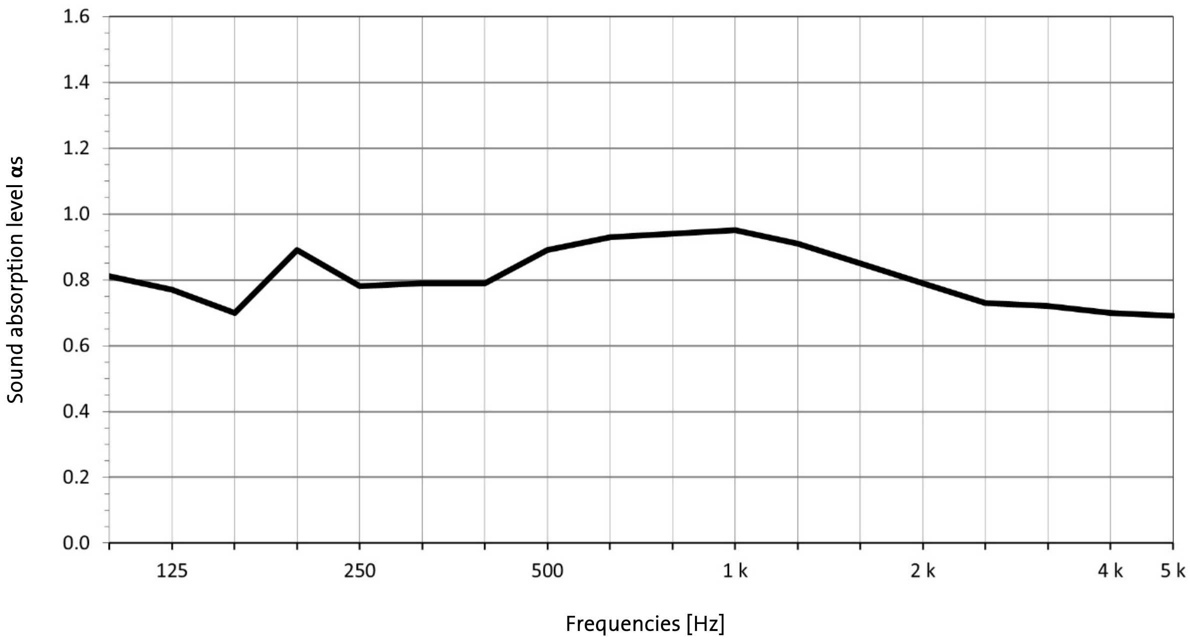


Fig. 6: Sound absorption curve over different frequencies using the example of a metal radiant ceiling with acoustic fleece and mineral wool mat

Fixtures (lighting, sensors, etc.)

The increasingly technical nature of office buildings means there is a need for places to install sensors. The fact that sensors on the ceiling have a good 'overview' makes ceilings a good place for fire alarms, motion detectors, carbon dioxide sensors, temperature sensors, etc.

Safety equipment, such as sprinklers, is also installed directly in suspended ceilings, as is lighting, the heat from which is conveyed away directly and efficiently by a radiant ceiling.

As all of these fixtures require cables, pipes and a power supply, there is a desire to conceal everything behind a suspended ceiling for architectural reasons.

Fig. 7: Radiant ceiling with perforated plasterboard panels and different fixtures (light, air, sprinkler, smoke detector)

Conclusion

The versatility of radiant ceilings, whether as suspended metal ceilings or seamless plasterboard ceilings, makes them ideal when it comes to meeting the high demands of today's office buildings.

They offer a convenient way to integrate heating and cooling, supply air diffusers, sound absorption, lighting and sensors.

Last but not least, radiant ceilings are also highly effective from an architectural perspective, acting as the 'jewel in the crown' of just about any room.

With more than 40 years' experience in radiant ceiling systems and room comfort, Barcol-Air would be happy to support you with your radiant ceiling projects. Get in touch!

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