KNOWLEDGE

FACTORS WHICH INCREASE THE CAPACITY OF RADIANT CEILINGS

Difference between EN 14240 and reality

BARCOL-AIR
by Swegon

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Introduction

The European standard EN 14240 defines test conditions and processes to determine the cooling capacity of radiant ceilings or other large cooling surfaces. The aim of this standard is to provide comparable and reproducible product parameters. However, conditions in a real office building are different from those in an EN 14240 test room. Some of these conditions have an extremely positive effect on the cooling capacity of radiant ceilings.

In the specially designed Barcol-Air climate laboratory, it is possible to simulate the capacity-boosting factors which occur in a real office building. This dokument is intended to show the difference between EN 14240 and reality, and to provide an overview of the factors which increase the capacity of radiant ceilings and what effect these factors have on the cooling capacity.

The use of radiant ceilings has become standard practice in modern office buildings. Their large heat exchanger surface allows room air conditioning with water temperatures relatively close to the room temperature. This makes them extremely energy efficient. Standardisation of measurements in accredited testing institutes was introduced at an early stage, to enable comparison of the different systems on the market.

A measurement of the cooling capacity to EN 14240 makes it possible to draw clear conclusions about the differences between the available systems. To keep the measurements as simple and reproducible as possible, the influences which exist in a real room are deliberately excluded from an EN 14240 test room – understandably so. However, most of the real influences have a positive effect on cooling capacity and lead to an increase in capacity. As a result, many radiant ceiling systems could therefore be smaller in size. Investment costs would also decrease, therefore.

This document addresses the following questions:

- What are the differences between the capacity measurement according to EN 14240 and real conditions?
- How significant is the effect of these differences?
- What factors increase the capacity of radiant ceilings in real buildings and how do these factors affect the cooling capacity of a radiant ceiling?

Factors which increase the capacity

Difference between EN 14240 and reality

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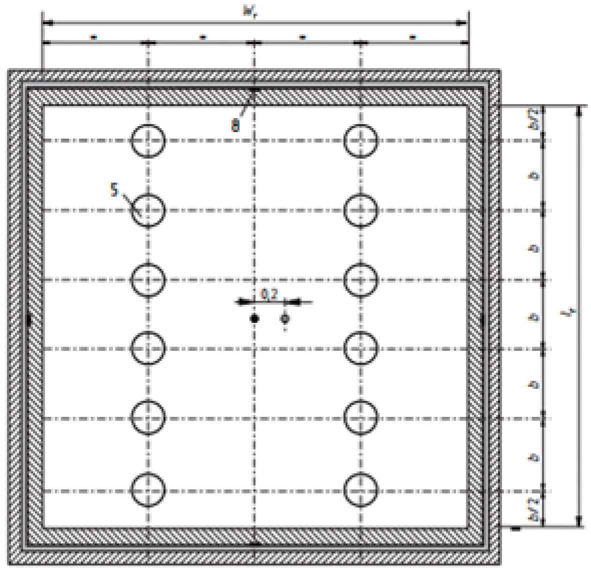
Measurements to EN 14240 – for clear comparison

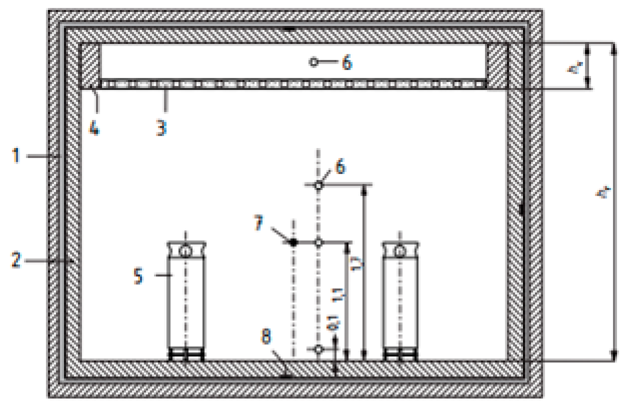
Standards for consistent measurement were drawn up at an early stage to enable comparison of different radiant ceiling systems. The currently applicable EN 14240 dates from 2004 and still leads to clear results – although with some details which would benefit from modification. Requirements which an EN 14240 test room must fulfil include the following:

- 10 to 21 m² floor area and 2.7 to 3 m room height (variations are permissible)
- A forced flow must not be imposed on the air in the test room (therefore mixed ventilation is not permitted, for example). The room must also be sufficiently airtight.
- Internal walls and floor must be temperature controlled and insulated so that the average heat flow does not exceed 0.4 W/m². The radiation emission factor of the surfaces on the room side should be >0.9.
- The heat balance of the equipment under test and the cooling load simulator (see next page), as well as the heat transmission within the test room perimeter, should not be more than 5 % of the measured cooling capacity – the walls must therefore be kept as isothermal as possible relative to the room.



Key

Test room (with regulated flow of water through perimeter walls and floor) with installed radiant ceiling, cooling load simulators and temperature measuring points.



1 Metal panels with water flowing through them

2 Thermal insulation

3 Equipment under test

4 Edge insulation panel (important with radiant ceilings)

5 Cooling load simulator

6 Air temperature measuring point

7 Globe temperature measuring point

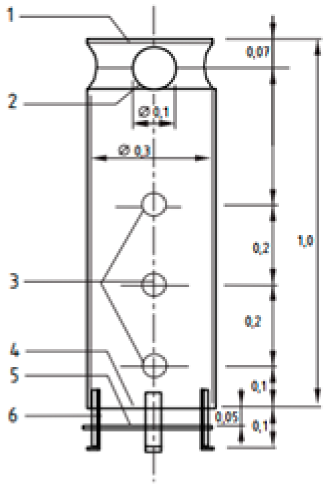
8 Measuring point for the temperature under the thermal insulation

Fig. 1: Example of test room from EN 14240:2004 (D)

Requirements regarding its technical equipment

In addition to the requirements for the test room itself, there are also requirements regarding its technical equipment:

- The energy to be dissipated is supplied to the room via an even number of standardised cooling load simulators. These are distributed symmetrically in the room (i.e. mostly in two rows parallel to the long side of the room).
- The cooling load simulators are made of coated sheet steel with an emission level (internal and external) of >0.9.
- The cooling load simulators must be infinitely adjustable up to 180 W per simulator.



Key

1 Cover

2 Holes evenly distributed around the circumference

3 Light bulbs each with 60 W

4 No base

5 Base

6 Feet, distributed around the circumference

Fig. 2: Cooling load simulator (dummy), source: EN 14240:2004 (D)

- The measuring devices will not be described further here, as they could also be used in this way in a real office room. It is important to note that a globe temperature sensor is used for the reference room temperature – i.e. a sensor which measures the mean value derived from the air temperature and the heat emission temperature (in the same way as a person also feels both temperatures together).

Influences on the cooling capacity in a real office – mixed ventilation

EN 14240 test room	Reality
According to EN 14240, a forced flow must not be imposed on the air in the room. This means that measurement of radiant ceilings in combination with supply air systems is not permitted.	Under real conditions, almost every modern office building has a controlled supply of fresh air. An increase in cooling capacity on the water side can be observed with virtually every type of supply air diffuser. However, the extent of this increase varies.

Comparison of increase in capacity due to supply air diffusers

System	Operating principle	Relationship to supply air temperature	Increase in capacity on the water side
Conventional baffle plate diffusers, swirl diffusers, slot diffusers	Air is blown out on the underside of the ceiling at high speed. It stays on the ceiling due to the Coanda effect. The heat transmission coefficient (α) on the underside of the radiant ceiling increases due to the high speed.	Slight; increase in capacity due to better heat transmission.	Approx. 5 %
AQUILO Hybrid system	The AQUILO is located in the ceiling panel. 80 % of the supply air is blown into the room between the heat conducting rails at low velocity. 20 % of the supply air flows out at high speed above the ceiling panel. The resulting induction effect draws warm room air onto the upper surface of the panel, which leads to a significant increase in cooling capacity.	Measurable relationship as the nozzles are located above the panel. However, an increase in capacity can only be expected when the supply air temperature is approx. 2 K above the water temperature.	5 - 20 % Depending on excess temperature of the air relative to the average water temperature.
CAURUS Hybrid system	The CAURUS is located above the ceiling panel and blows out 100 % of the supply air between the room ceiling and the ceiling sail at high speed. The resulting induction effect significantly increases the cooling capacity of the ceiling panel – the special shape of the induction nozzles prevents draughts in the room space at the same time.	Slight; the supply air always remains above the ceiling panel.	20 %

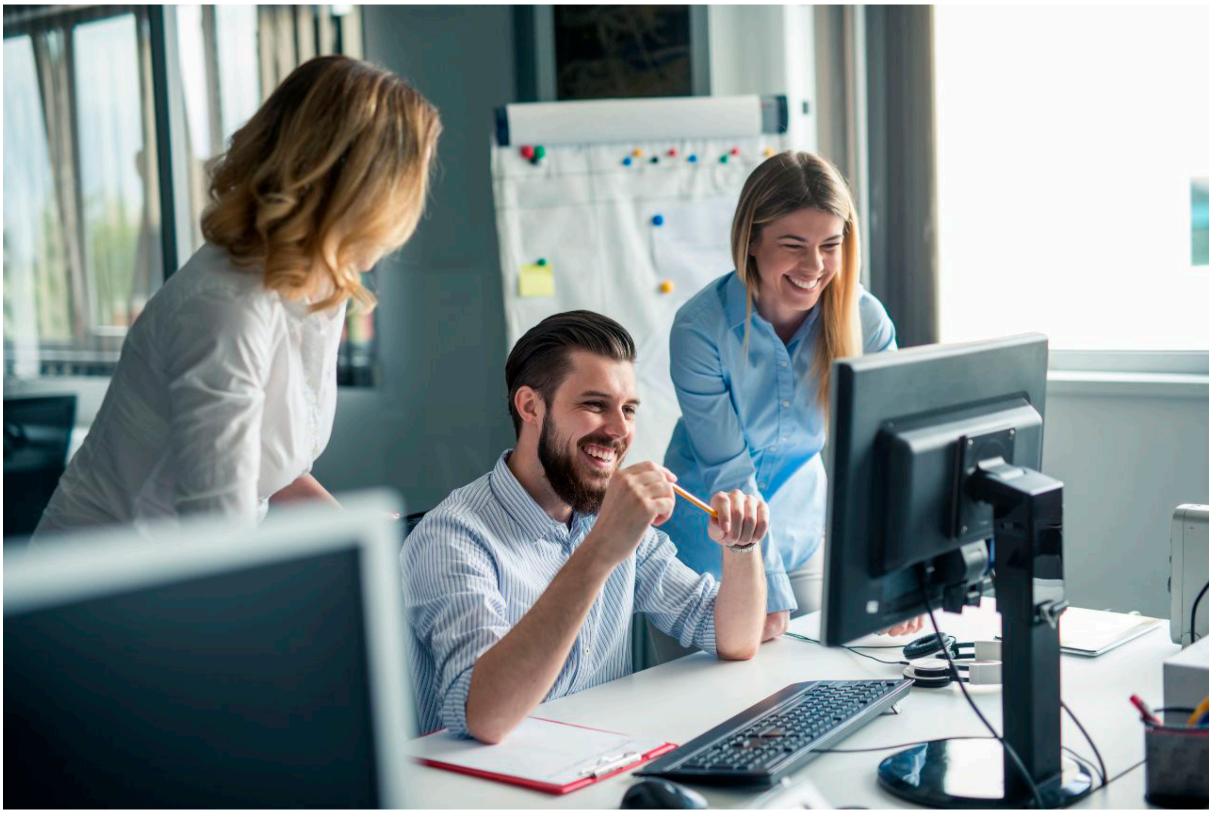
Fig. 3: Comparison of conventional and specialised supply air diffusers

Influences on the cooling capacity in a real office – warm façade

EN 14240 test room	Reality
The perimeter walls in the EN 14240 test room are isothermal: they emit very little energy to the test room and absorb very little from it. This means there is no increase in room air flow caused by the heating of air along the façade.	In a real room, the façade is often the warmest place in summer. Huge air masses rise here, which then dominate the circulation of the room air as it continues to flow – even supply air diffusers oriented directly towards the façade barely counteract this. Due to the large quantities of air which are moved by the warm façade, it has a major influence on the cooling capacity under real operating conditions. However, the proportion of glass and the interior surface temperature must also be factored in. With an interior surface temperature of 32 °C and a façade consisting of 75 % glass, an 8 % increase in capacity can be assumed.

Influences on the cooling capacity in a real office – asymmetrical load distribution

EN 14240 test room	Reality
The symmetrical positioning of the cooling load simulators leads to a symmetrical room air flow. The air rises from the middle of the room in two large updraughts, cools on the ceiling, and then falls to the floor – most of it along the walls of the room and a small part of it between the simulators. This movement is relatively gentle (<10 cm/s).	In a real room – particularly in large offices – the loads are instead concentrated at individual points in the room: the workstations. Each workstation has lighting, a computer, a monitor and, of course, the person who works there. Both the people and the equipment give off heat. The workstation situation leads to a local uplift zone, which means that the air rises at a somewhat higher speed than it does with the evenly distributed cooling load simulators. However, provided that the equipment used does not output an exceptional amount of heat, this has only a minor influence, with an increase in capacity of just 3-5 %.



Influences on the cooling capacity in a real office – building mass storage

EN 14240 test room	Reality
The perimeter walls in the EN 14240 test room are very well insulated and should neither absorb nor emit any energy, to enable comparison of different products in different testing institutes. Cooling capacity measurements to EN 14240 (pertaining to room temperature, room surface temperature, water temperature and flow rate of the cooling water) are carried out at a steady state. A steady state is reached when the values have been "settled" for at least 60 minutes. This procedure is necessary to allow comparison of the capacity values.	However, in real buildings – and as required by an increasing number of standards – the perimeter walls must be solidly constructed. Since solid structural components have a higher heat storage capacity, this saves cooling energy. In a real office building, the loads (and therefore the room temperature) are not always the same over the course of the day, leading to a fluctuation in the room temperature throughout the day. Peak loads can be stored temporarily in the solid perimeter walls and do not need to be directly dissipated. This saves costs for both energy and installation.

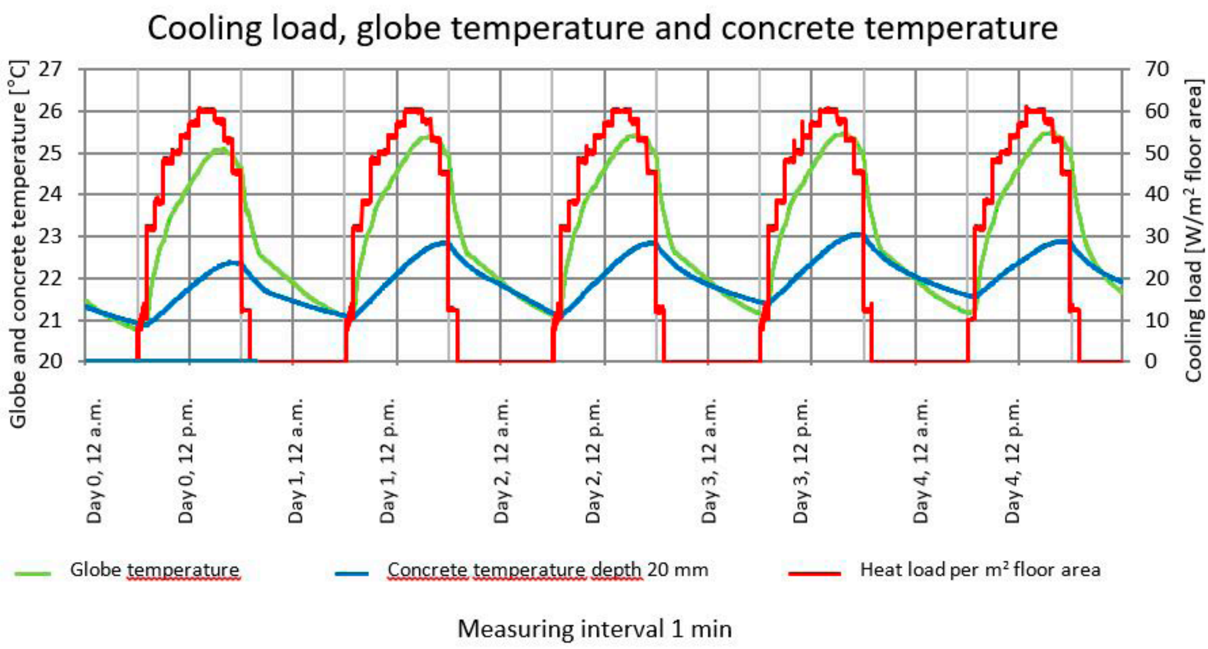


Fig. 4: Barcol-Air has various radiant ceiling systems which make optimal use of the mass storage effect. The graph shows a dynamic cooling capacity measurement with the U4X Hybrid system. Five simulation days are shown, with the daily heat load cycles and the resulting fluctuations in room temperature. These cycles cause the concrete to absorb energy during the day and give it off again at night.

Recommendation document:

«Radiant ceilings with building mass connection»

Summary

The factors and their potential for increasing capacity in real office buildings

In a real office building, each individual factor leads to an increase in the cooling capacity values identified by applying EN 14240. Due to two factors in particular – ventilation and warm façade – a 12 % increase in capacity can be assumed compared to the measurements according to EN 14240 (assuming that virtually every office building has to be ventilated, and the cooling capacity is primarily required when the outside temperature is high – and therefore the façade is warm).

Factor	Operating principle	Increase in cooling capacity[1]
Mixed ventilation – conventional Supply air diffusers	Improved heat transmission coefficient on the underside of the radiant ceiling.	+ 5 %
Mixed ventilation – Barcol-Air supply air elements	Induction of warm room air onto the upper surface of the radiant ceiling (also increases the mass storage capacity, see below).	+ 5 - 20 %
Warm façade	Very strong room air updraughts, which convey the warm air from the façade to the radiant ceiling at relatively high speed.	+ 6 - 8 %
Asymmetrical loads	Concentration of the workstations and their cooling load in a few areas of the room.	+ 3 %
Mass storage capacity	Can be significantly increased by cooling of the concrete ceiling at night and "charging" during the day.	+ 5 - 20 %

Fig. 5: Factors and values for increased cooling capacity in a real office building

[1] Excluding the cooling load dissipated via the supply and extract air.

Conclusion

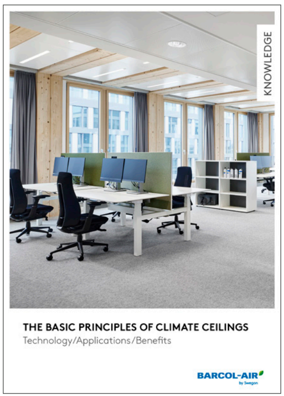
Although EN 14240 achieves correct results in the context of comparing different products, the conditions in a real office building vary greatly from those in a test room. Furthermore, most of these real conditions have a positive influence on the cooling capacity of radiant ceilings. Two factors, which are present in practically every office building – ventilation and warm façade – can increase the capacity values of a radiant ceiling by 12 %, leading to direct effects on the sizing of radiant ceilings and therefore ultimately the investment costs and operation of the system (flow temperature, water volume, etc.).

It is therefore very important to take real conditions into account. The specialists at Barcol-Air have very precise knowledge of the factors which increase capacity and can support you with the sizing of your radiant ceiling projects. In the specially designed climate laboratory at the Barcol-Air company head office, projects can be simulated with capacity-boosting factors which occur in real conditions and be verified at the planning stage.

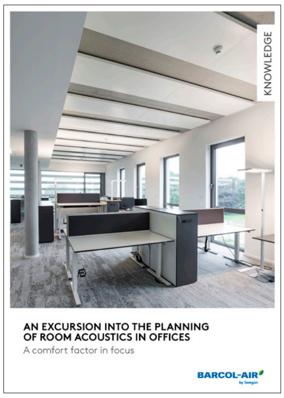
Notes

Other documents with facts and insights

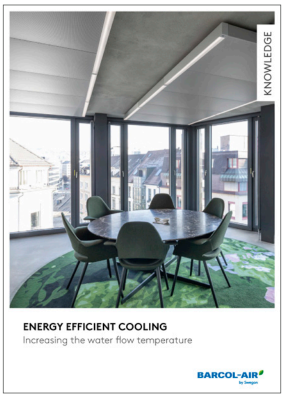
The basic principles of radiant ceilings
Technology/Applications/Benefits



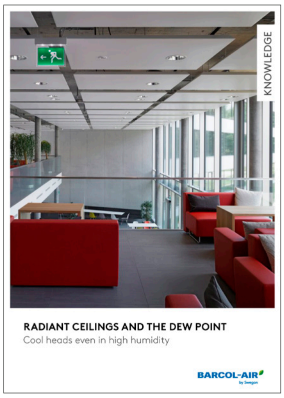
Planning room acoustics in offices
A comfort factor in focus



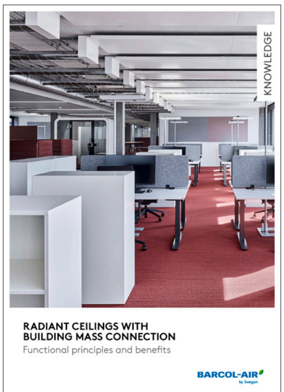
Energy efficient cooling
Increasing the water flow temperature



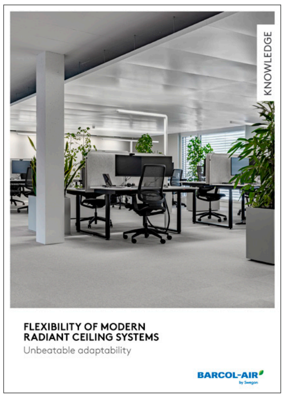
Radiant ceilings and the dew point
Cool heads even in high humidity



Radiant ceilings with building mass connection
Functional principles and benefits



Flexibility of modern radiant ceiling systems
Unbeatable adaptability



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