BARCOL-AIR




Chilled Ceiling Technology

Type CBA-C

REDEC

Benefits

- 100% reproducable performance due to factory finished activation of panels
- The heat conducting rails are bonded to the reverse side of the panel utilizing a permanently elastic material which ensures a highly efficient heat transfer and adds rigidity to the ceiling panel
- Minimal water resistance
- Calibrated copper tubes 12 mm dia. (10 and 15 mm dia. also possible)
- Fast and effective and economic installation through the use of push-on quick release couplings
- The greatest percentage of cooling is achieved by radiation ensuring a high comfort level.
- Draught-free cooling in accordance with DIN, ISO and SIA standards

Application

Due to the high cooling capacity, the patented design and excellent acoustic qualities, the REDEC chilled ceiling system type CBA-C provides the client and consultant, architect and the contractor with a highly flexible system.
REDEC can be used with any powder coated metal ceiling panel and is easily incorporated into either new or renovated buildings. It can be utilized in cellular and open plan offices, department stores, research and development laboratories, as well as production and assembly areas.

Typical Panel Design

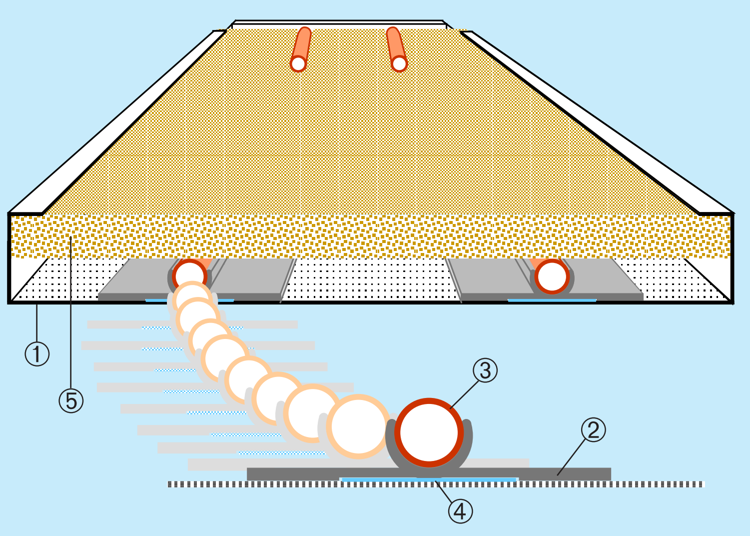
Metal Ceiling Panel
fig 1.1 Pos. 1
The ceiling panel, normally manufactured from 0,7 mm thick zinc coated steel plate, powder coated approx. 80 µm thick to colour code RAL 9010 sfs (semi-matt fine structure finish), is perforated 2,5 mm dia. to provide 16 - 25% free area. Other colours, perforations and panel material are possible as supplied by most panel manufacturers.

Heat Conducting Rail
fig. 1.1 Pos. 2
The heat conducting rails are manufactured from high precision extruded aluminium profiles with a black anodised finish. The rails are specifically designed to accomodate the calibrated copper tube

Heat Conductive Permanent Bonding
fig 1.1 Pos.4
The aluminium heat conducting rails are secured to the reverse side of the ceiling panel by a unique bonding process. The technique utilises a special permanently elastic material which ensures a highly efficient heat transfer to the panel surface.

Acoustic Inlay
fig 1.1 Pos 5
The acoustic inlay mineral fibre would be typically 30 mm thick with a density of 40kg/m³. The inlay is sealed in an air tight black plastic sheet, ensuring no fibres are being released. The chosen materials provide an optimum sound absorbtion. The acoustic performance of an inlay system is not affected by the depth of the void. If an acoustic fleece (which is available as an option) is used instead of inlay system, the acoustic performance is influenced by the depth of the void.

1.1



Calibrated Copper Tube
fig. 1.1 Pos. 3
The standard diameter used is 12 mm. The high precision tube and the extruded rail are assembled under pressure, thereby creating a continuous contact between the two surfaces throughout their entire length. Instead of the copper tube, a precision zinc-coated steel tube can be used.

Ceiling Panels

fig. 2.1
The dimensions of the ceiling panels can be chosen to suit the architectural design of the ceiling. Most panel dimensions produced by the panel manufacturers are possible. The standard distance between the heat conducting rails is 150 mm with copper tube dia.12 mm. The minimum distance from the edge of the panel is 50 mm. The distance between each rail can vary to allow for different cooling capacities. Ceiling panel manufacturers can incorporate a range of design options into the panel edge detail to accomodate a variety of mounting systems e.g. C-profile / bandraster / H-profile etc. Furtermore where the architectural design requires spaces between each panel, distance pads or space strips can be included to maintain uniformity of appearance.

2.1

The Architectural Design of the Ceiling

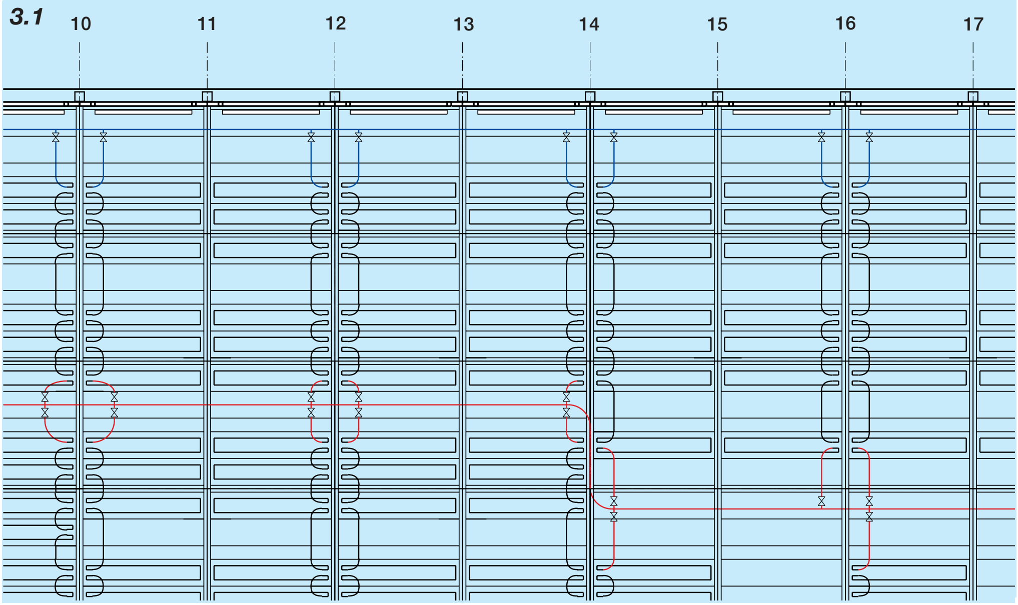
Almost any shape, preferably flat but also curved, can be chosen by the designers to accomodate the architectural requirements of the buildings.

fig. 3.1
A very typical design is shown in fig 3.1. Taking the window axis as a centre line, a support grid is mounted which in turn is used to retain the panel but also allows the mounting of the supports for the room dividing walls. This system is especially suitable for buildings in which a high degree of flexibility is required.

The number of active and inactive panels is governed by the cooling load for the area. Active and inactive look alike when viewed from the room. To allow for building tolerances, inactive panels are mounted at the edge of the room and cut to suit the room geometry. In offices where the cooling load is relatively low, the active panels are mounted in the window area where the largest heat input can be expected.

Since no restrictions concerning the panel dimensions exist, any building structure and architectural design in respect of ceilings can be accomodated.

3.1



4.1

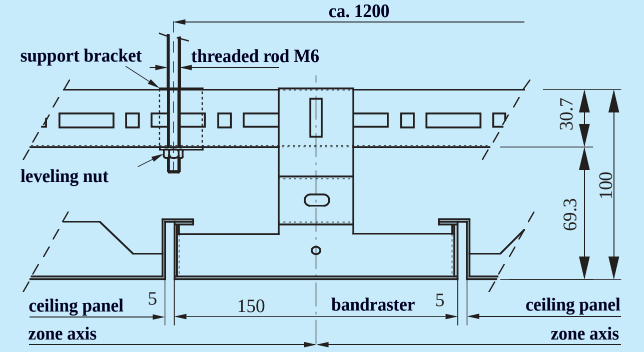
Access to the Ceiling Void

It is normally possible to gain access to the void by moving an inactive ceiling panel. The use of flexible hoses with sufficient length enables each active panel to be lifted and moved to one side. This feature makes it possible to free a large area, providing good accessibility for maintenance of components mounted in the void. If required, the ceiling panels can be supplied with specially designed hinges and locks to facilitate the access to the void.

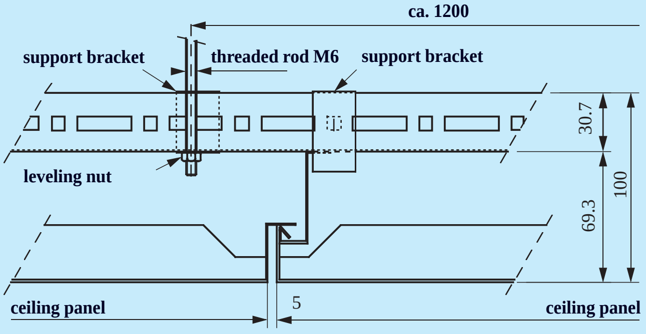
Special Design Features

The REDEC chilled ceiling system is designed to allow for all known variations of existing metal ceilings, i.e. support grid systems and hidden support systems, (see fig. 4.2, 4.3). It easily accomodates lighting equipment, double edging strips (see fig. 4.4) and loudspeakers, as well as supply air diffusers. Fire protection systems i.e. sprinklers and smoke detectors can also be intergrated into the ceiling.

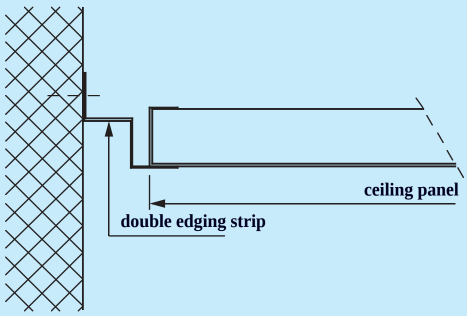
4.2



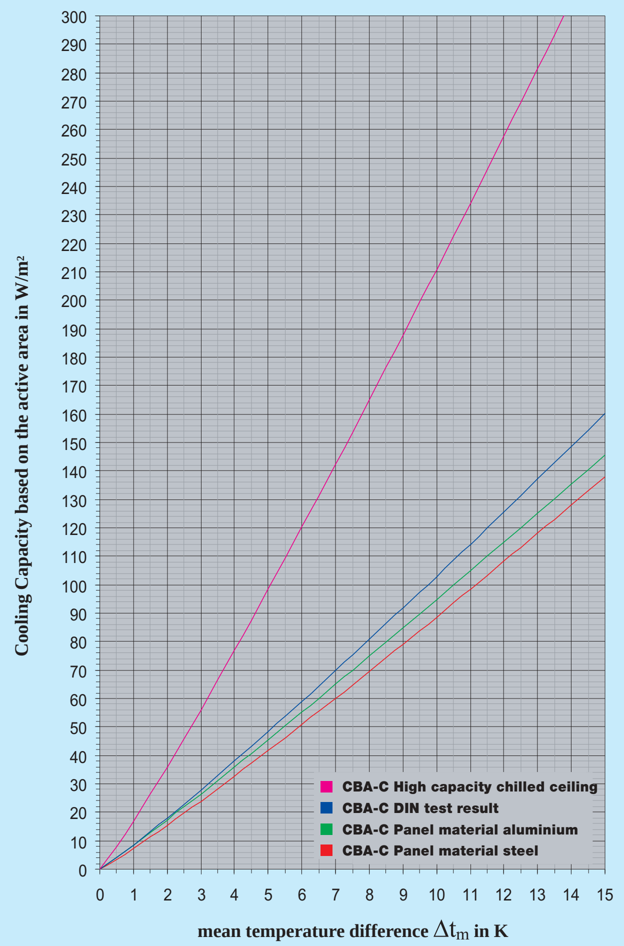
4.3



4.4



5.1



How to Determine the Specific Cooling Capacity

Standard Cooling Capacity

Fig. 5.1 shows the cooling capacity line determined in accordance with the DIN 4715-1 standards, part 1 as a function of the mean temperature difference Δt_m. The standard cooling capacity is related to applications with the following conditions:

- room height of 2,7 m
- 70% active area
- no fresh air supply from the ceiling
- symetric arrangement of the heat sources in the room
- thermal storage of the building substance must not be considered
- ceiling panels perforated, 16% free area

The blue line is valid for ceiling panels made of steel plate, 0,7 mm thick. The distance between the heat conducting rails is 150 mm.

The yellow line is valid for panels made of aluminium, 1 mm thick. The distance between the heat conducting rails also at 150 mm. The DIN test was carried out with heat conducting rails center to center 80 mm. (sec. VF 99 K 24.1337). The standard cooling capacity can be inereased to well above 200 W/m² and stil fulfill the DIN- ISO- and SIA standards coneerning comfort condition in the room, with the aid of additional equipment installed in the void.

How to Determine the mean temperature difference Δt_m:

$$\Delta t_m = t_R - ((t_{Wi} + t_{Wo})*0,5)$$

Δt_m = mean temperature difference K
t_R = room air temperature °C (dry bulb)
t_{Wi} = temperature water inlet °C
t_{Wo} = temperature water outlet °C

Whenever the difference between the room air- and the water outlet temperature is less than 6 K one has to use the logarithmic instead of the arithmetic average temperature difference.

$$\Delta t_m = (t_{wo} - t_{wi}) / \ln((t_R - t_{wi})/(t_R - t_{wo}))$$

Correction Factors for Different Applications

Combining the chilled ceiling with the fresh air inlet from the ceiling produces an increased air circulation thus increasing the specific cooling capacity up to 5%. The exact %-value is dependent on the type of diffuser and the corresponding air movements. In case of asymetric arrangement of the heat sources in the room the cooling capacity is increased up to 5%.

The influence of the room ceiling height is calculated by using the following formula:

$$\dot{q} = \dot{q}_n * f_H$$

$\dot{q}$ = specific cooling capacity at the room ceiling height H
$\dot{q}_n$ = specific cooling capacity as shown in diagram fig 5.1
f_H = correction factor for different heights

Height m:	2,40	2,70	3,00	3,30
Factor f_H	1,046	1,000	0,954	0,913

Further features which increase the standard cooling capacity are:

- open gaps between wall and ceiling
- increased temperature of the concrete ceiling e.g. due to heat transmission (solar gains)
- intensive illumination devices
- high temperatures of the facade
- ceiling grid systems which are in direct contact with the chilled panel

The determination of the cooling capacity for special applications can be provided on request.

How to Determine the Pressure Loss of the Copper Tube 12 mm Dia.

The excellent heat conduction from the surface of the active panels to the chilled water of the REDEC system is based on a high internal heat conduction co-efficient (α internal) applicable to turbulent flow.

The diagram in fig 6.1 shows the resistance of one heat conducting rail with a copper tube of 12 mm diameter as a function of the circuit water volume and the length of the heat conducting rail. In order to determine the total circuit resistance, the value derived from the diagram must be multiplied by the number of panels and heat conducting rails (HCR) connected in series and added to the resistance of all flexible hoses in the circuit.

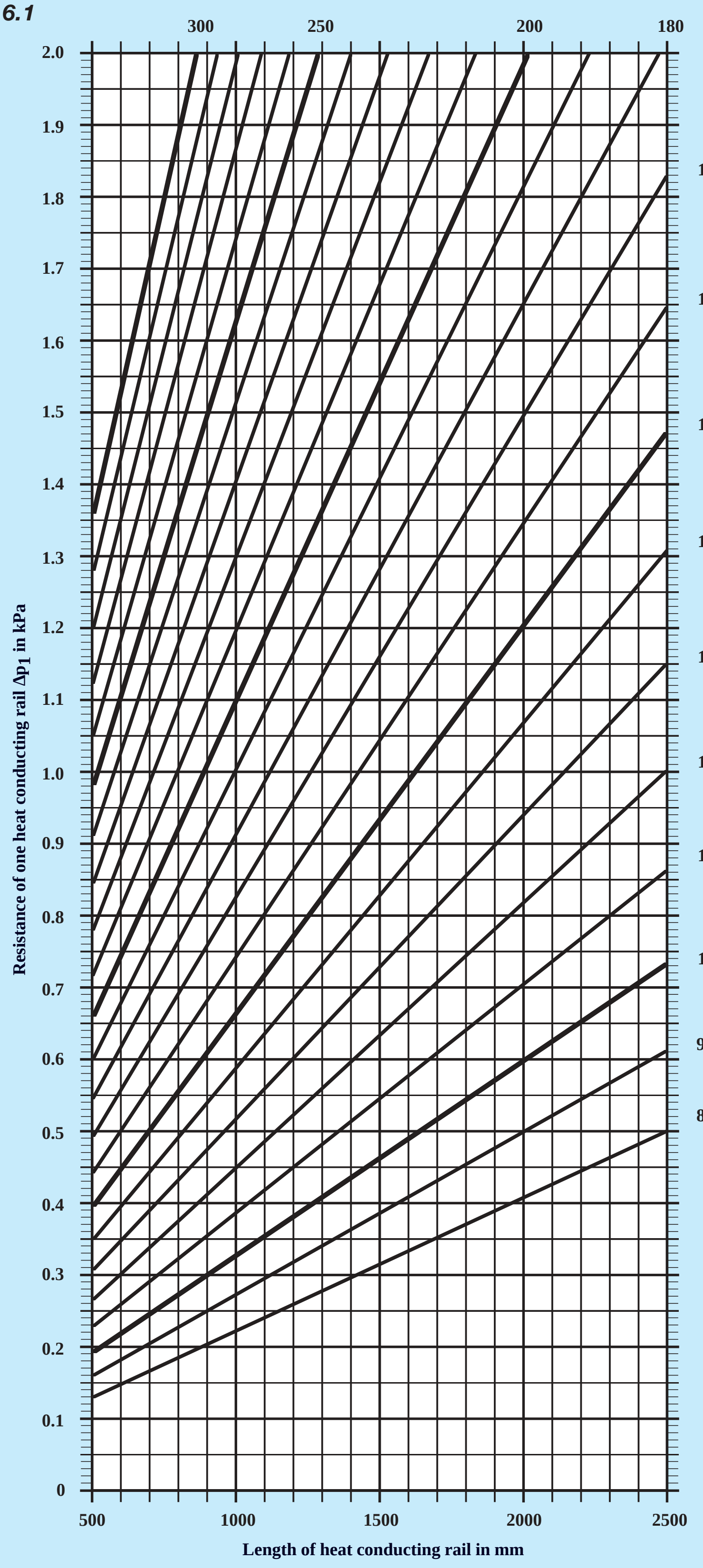
$$\Delta p_{tot} = (\Delta p_1 * n_P * n_{HCR}) + \sum \Delta p_c$$

Δp_{tot} = total resistance of the circuit
Δp_1 = resistance of one heat conducting rail according to diagram 6.1
n_P = number of panels in series
n_{HCR} = number of heat conducting rails on each panel
$\sum \Delta p_c$ = resistance of the flexible connectors, as indicated in the section Hydraulic

Minimum Water Flow

In order to obtain turbulent flow conditions the water quantity of the circuit should not be below 70 l/h for the 12 mm tube. This can be achieved by connecting the necessary number of panels in series. In situations where turbulent flow can not be achived, the specific cooling capacity must be corrected accordingly.

6.1



Hydraulic Circuits

When planning the chilled water distribution it is preferable that the water circulation through the active area is from the window area to the centre of the room. Due to the large tube cross section used on the panels it is possible to connect all panels of one zone in series. This means that only the first and the last panel of the zone must be connected to the mains.

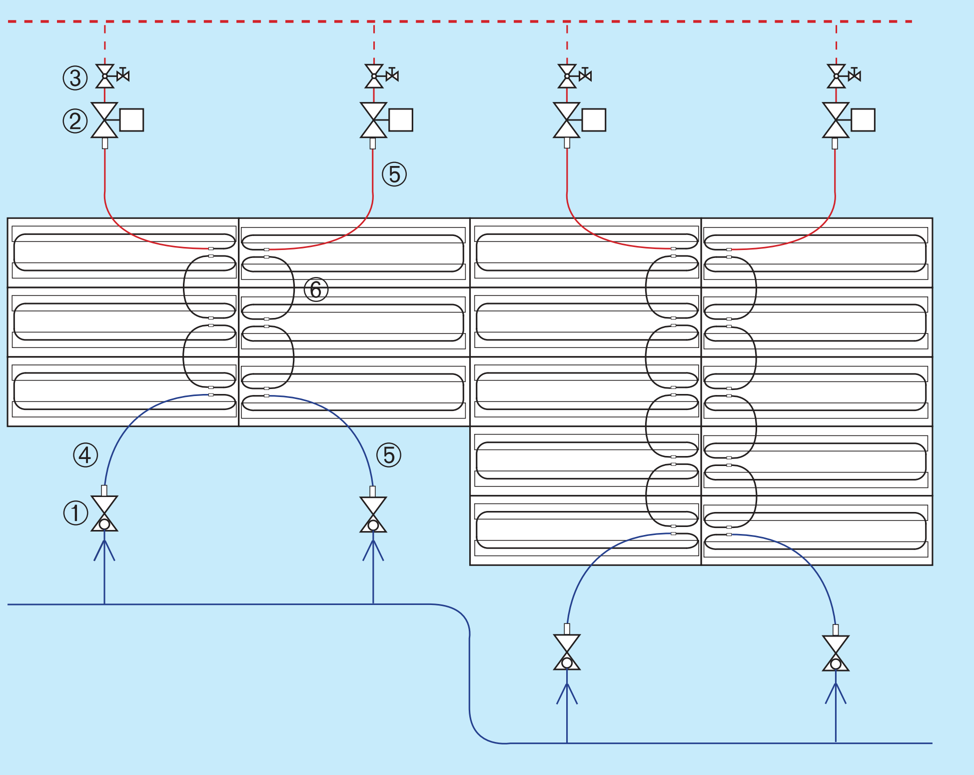
The water connections to the mains are in accordance with the room or zone layout. In large rooms or large zones active areas should ideally have the same number of panels in series (equal water distribution). In cases where this is not possible the individual water circuits must be adjusted with appropriate throttling devices, see fig. 7.1

Generally it is recommended that the individual water circuits of the active areas should be isolated from the mains by means of a ball type valve on the water inlet and outlet branch, see fig. 7.1 (Pos. 3 and 4). The advantages of this method are particularly useful during commissioning work or where alterations have to be made at a later date. During commissioning, the main water installation can be pressure and leak tested with closed ball valves and changes in an active zone can be done without draining the complete system.

The control valves regulate the water quantity in the active zone dependent on the cooling requirements. An inline valve is sufficient for most applications. For further information see under section Controls in this brochure.

For the connection of panels to the mains inlet and outlet as well as the inter connection of the panels in series, flexible all metal bellow type hoses are available, see fig. 7.1 (Pos. 5 and 6). No oxygen can permeate through the flexible all metal hoses into the chilled water. The flexible hoses are provided with high quality push-on couplings. In order to use the push-on couplings together with the installed armatures a specially designed nipple is available, see Fig. 7.1 (Pos 4).

7.1



1 water volume distribution valve
2 control valve
3 ball-type isolating valve with/without air vent/draining valve
4 nipple
5 flexible connecting hose with push-on couplings
6 flexible connector with push-on couplings

Details of Hydraulic Components

Fig. 7.2 shows the flexible all metal bellows type hose with push-on couplings at both ends. No oxygen can permeate through the hose into the chilled water circuit.

Technical Data of the All Metal Hose

stainless steel material code 1.4541
push-on coupling: Legris DN 12
max. operating pressure: 9 bar
dimensions: DN 10 x 1000 mm long
kv-value: 1,31 m^3/h

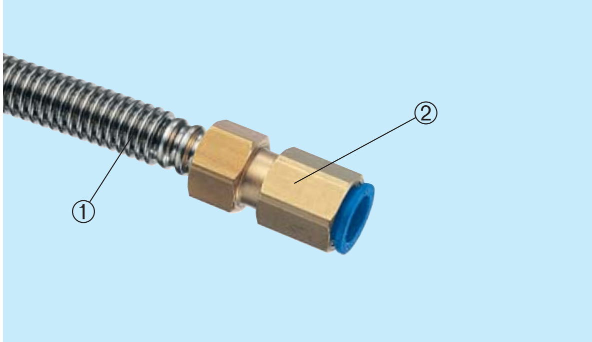
How to Calculate the Resistance of One Hose given:

all metal flexible hose
kv-value = 1,31 m^3/h
L = 1000 mm, DN = 10, bent 180°,
water volume m = 180 l/h
(0,18 m^3/h)

unknown:

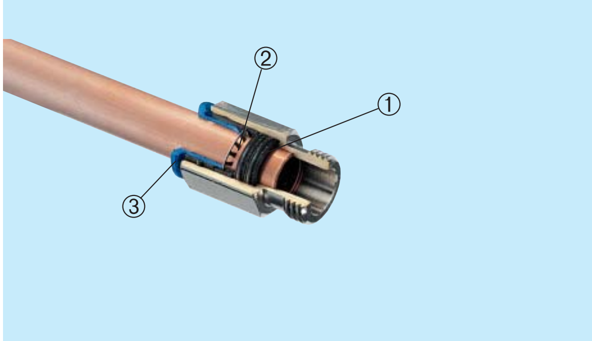
Resistance Δp
Δp = (m/kv)^2*100
= (0,18/1,31)^2*100 = 1,888 kPa

7.2



1 metal flexible hose
2 push-on coupling

7.3



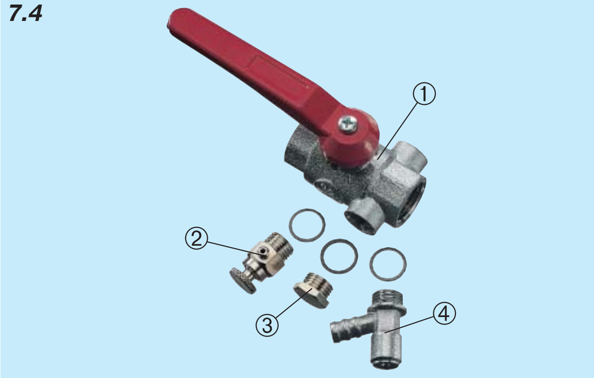
1 double profile ring made from VITON
2 segment ring made of stainless steel
3 dismantling release ring

Fig. 7.3 shows the push-on coupling which has been specially designed for use with chilled ceilings. The seal is achieved by means of a double profile ring. The coupling hooks on to the copper tube using a segment ring made of stainless spring steel. The advantage of this push-on coupling is found in a very simple, reliable connection and disconnection as well as in the superb production quality.

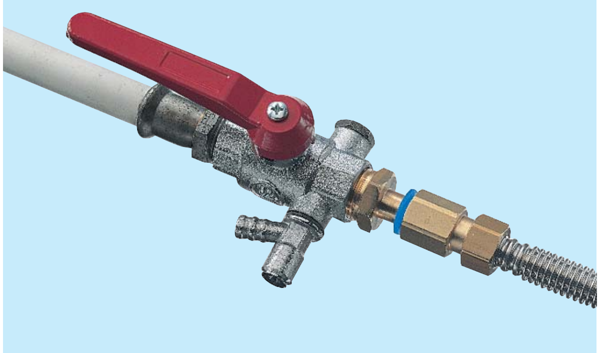
When fitting the push-on coupling onto the copper tube end, the unit is lined up with the tube and using light pressure, pushed in the direction of the tube until it has reached the tube stop. When dismantling, the release ring (3) is pushed in the direction of the coupling (disengaging the segment ring) and the flexible hose can be pushed off the copper tube.
Attention: The coupling must only be disconnected after the zone pipework has been drained.

1 ball type isolating unit
2 air vent valve 1/4"
3 seal nut 1/4"
4 combined vent/drain valve 1/4" with hose sleeve

7.4



7.5



7.6

Ball type isolating valves, readily available on the market, can be used on the water inlet and outlet branch. Fig. 7.4 shows a ball type unit with the possibility of integrating an air vent/draining valve.

This type of ball valve is recommended for installation in the water outlet branch whereby the vent/draining valve should be on the active panel side and not on the main water distribution side, see Fig 7.5. Thus when required the active panels can be de-pressurised and drained.

Fig 7.6 shows the screw-in nipple which can be tightened and screwed into the 1/2" BSP thread of the isolating valve using appropriate sealing materials. The stud is machined (12 mm dia.) to receive the push-on coupling of the connecting hose. The nipple can be used on both sides, the water inlet and outlet.

To balance the water quantity of the different active zones, standard balancing valves with connectors for measuring equipment can be installed.

With regard to control valves, see section Controls.

Acoustic

In occupied areas, the sound reverberation factor is reduced to the required level by using sound absorbing materials on the rooms surfaces. A very important area is the ceiling of the room. The useful sound absorbing ceiling area is the perforated part on which the sound absorbing material has been placed.

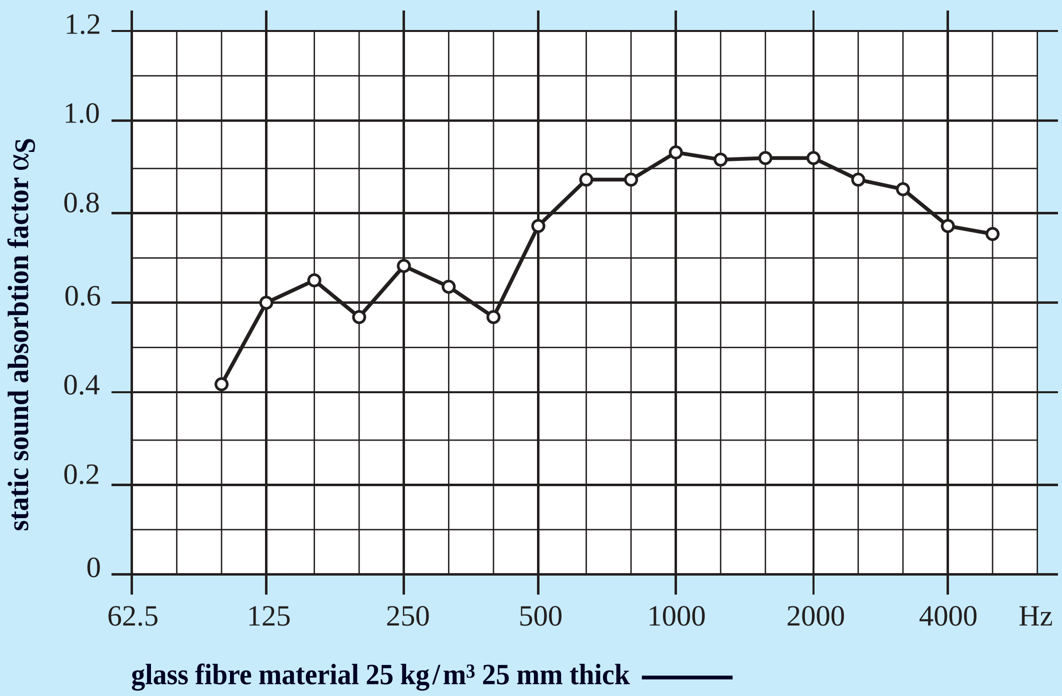
The diagram, Fig. 8.1, shows the sound absorbtion factor α_S as a function of the frequency for a standard ceiling panel of the following description:

- steel panel, material 0,7 mm thick
- perforated with 2,5 mm dia holes, 16% free area
- sound absorbing inlay, glass fibre, material 25 mm thick, weight 25 kg/m³

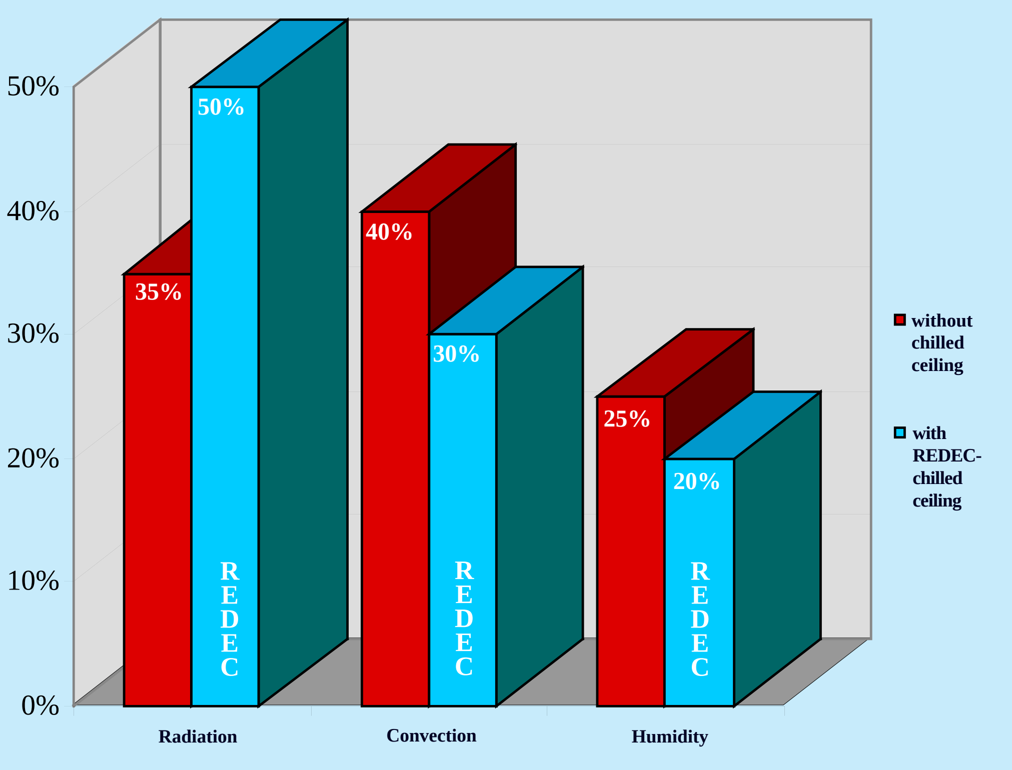
The main factors influencing the sound absorbtion are:

- the panel material and the type of perforation
- the physical properties of the sound absorbing material
- the geometry of the ceiling

8.1



9.1



The Principle of Heat Absorption

Radiant Chilled Ceilings

Radiant chilled ceilings offer a high degree of thermal comfort with no draughts even in rooms with high heat gains.The radiant heat exchange reduces the degree of convective air movements in a room and results in a high level of comfort.

Fig 9.1 shows the metabolic heat transfer of human beings in situations with and without radiant chilled ceilings.

Radiant Heat

Radiant heat is understood to be the energy which is emitted from bodies by means of electromagnetic waves in the range of 0,02 to 800 µm. For the total emitted radiation in a known specified area and time unit, the equation of Stefan Bolzman is applicable.

$$E = \varepsilon * C_S * (T/100)^4$$

E = emitted radiant energy in W/m^2

ε = emission ratio

C_S = radiation coefficient of a black cube 5,67 $W/m^2 K^4$

T = absolute temperature in K

Solid materials absorb the non reflective radiation so intensively, that no radiation can penetrate through the layers of even a few hundredths of a millimeter in thickness. In these circumstances one speaks of the radiation of technical surfaces. The table 9.2 shows the emission ratio of different surfaces.

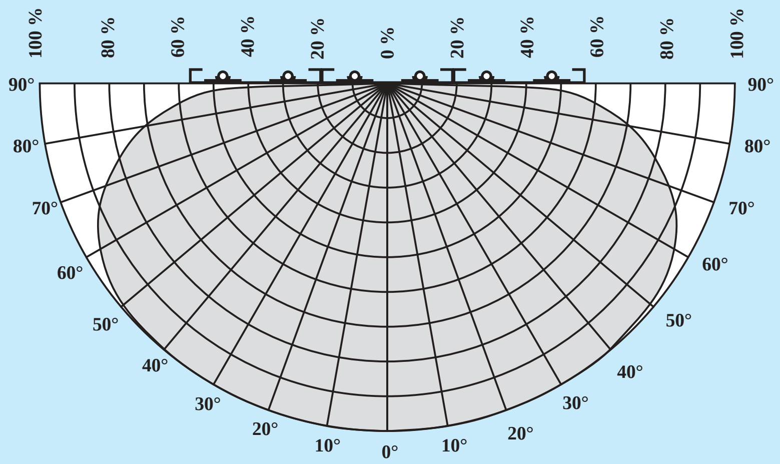
Fig. 9.3 shows the effect of heat radiation at different angles. A particular surface element absorbs radiant energy from all directions. The absorbed radiant energy is not affected up to an angle of 50°. At an angle of 75° the absorbed radiant energy is still 78% compared with the value at a right angle to the surface. The most important advantage of the REDEC radiant chilled ceiling results from this observation - namely - the large area effectively covered.

9.2

surface	emitting ratio ε
absolute black cube	1,0
bricks, plaster, mortar, gypsum	0,93
timber (beech)	0,94
paper	0,92
tiles (white)	0,87
porcelane	0,92–0,94
glass	0,94
earthenware	0,91
concrete	0,94–0,99
aluminium blank finish	0,04
steel raw	0,75–0,81
steel brushed	0,24–0,45
steel zinc coated matt finish	0,08
steel zinc coated	0,22–0.28
copper bright	0,07
copper black oxidated	0,78
brass polished	0,05
brass burnished	0,42
aluminium bronze paint	0,20–0,40
radiator paint	0,93
red lead paint	0,93
oil paint	0,88–0,97
powder coating of ceiling panels	0,90–0,95

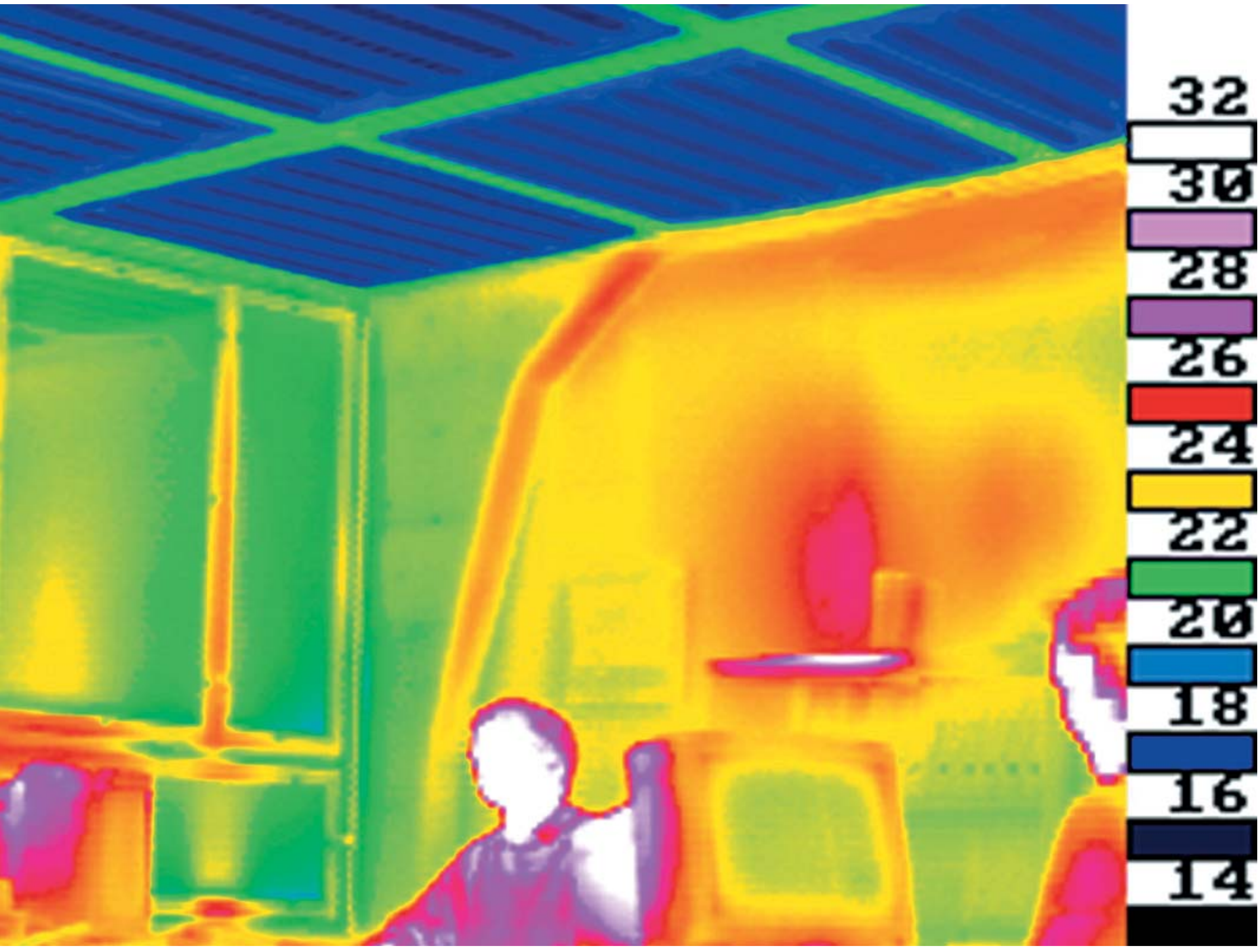
9.4

9.3



Due to the special design features of the REDEC chilled ceiling components, and the selected materials, optimal thermal conductive contact is achieved between the chilled water in the tube and the ceiling surface of the room. The resulting minimum temperature, spread equally over the total surface combined with a high quality powder coated surface finish (ε = 0,9 - 0,95) ensures heat absorbtion with the highest amount of radiation i.e. 60 - 70%.

The infra-red image, fig. 9.4 clearly illustrates the relationship between cold and warm surfaces as defined in the technique of heat radiation.



Control of Chilled Ceilings

Where variable internal and external heat loads prevail, the cooling output of a chilled ceiling is varied with the aid of a simple room controller. Normal control is achieved by throttling the water flow. The relatively small water content and the optimal selection of the material used on REDEC chilled ceilings ensure a fast reaction to any changes in heat load. The resulting control characteristics are comparable with those achieved with air systems. Normally the algorithm PI-reaction is selected with a proportional band of 1 K and a re-adjustment time of 10 minutes. Using such control, large heat load changes can be corrected quickly with stable results. An unintentional drift of the room air temperature, which would negatively influence comfort does not there-fore occur.

In order to achieve a stable control circuit, the correct sizing of the control valve is important. It is recommended that the valve authority is between 0,5 and 1. This means that the pressure drop, when the valve position is fully open, is equivalent to factor 0,5 - 1 of the pressure drop calculated for the zone circuit. To avoid sedimentation it is recommended not to install valves with kv values smaller than 1 m³/h. In zones where more than one control valve is installed, care should be taken that all valves operate in parallel.

To avoid condensation, the chilled water temperature must always remain above the dew point of the room air. This must be achieved by the consequent control of the chilled water flow temperature.

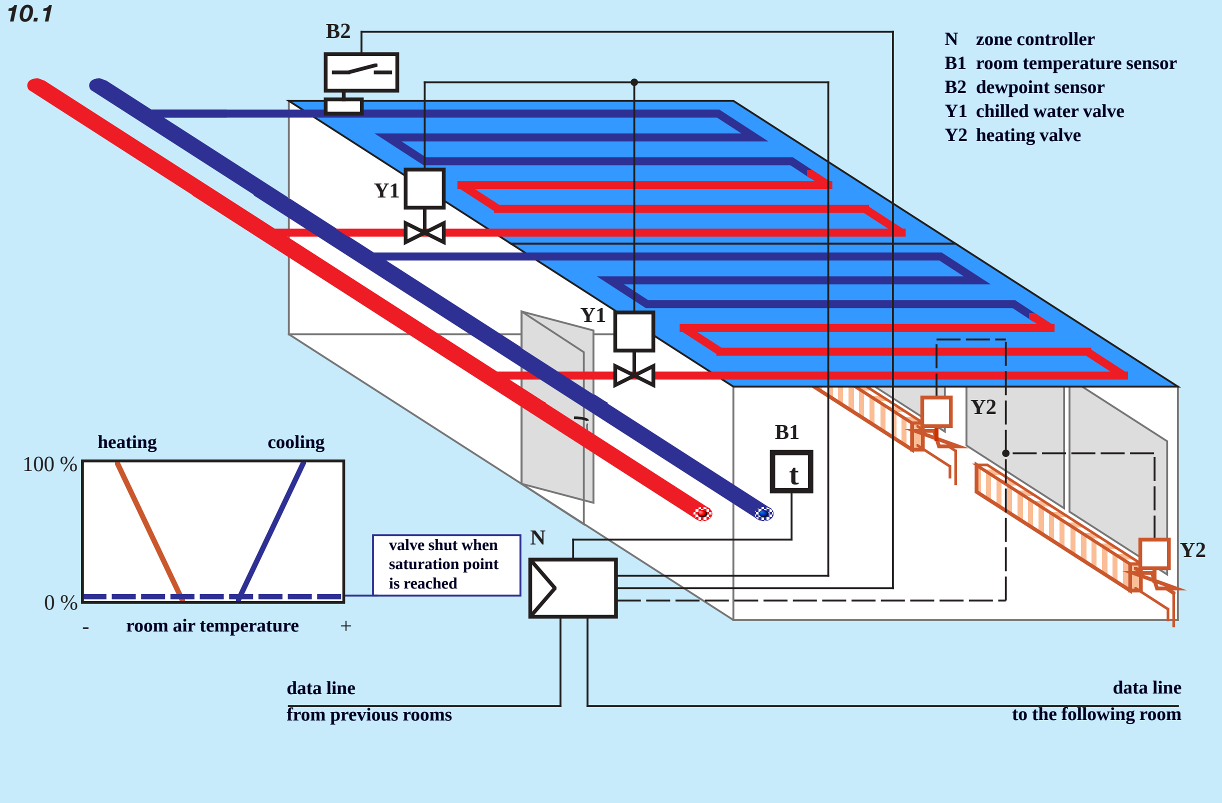
To eliminate any possibility of condensation, it is recommended to install a dew point sensor into each zone as a safety precaution. Prior to reaching critical saturation, the sensor would react and as a result the control valve would prohibit any water circulation in the zone.

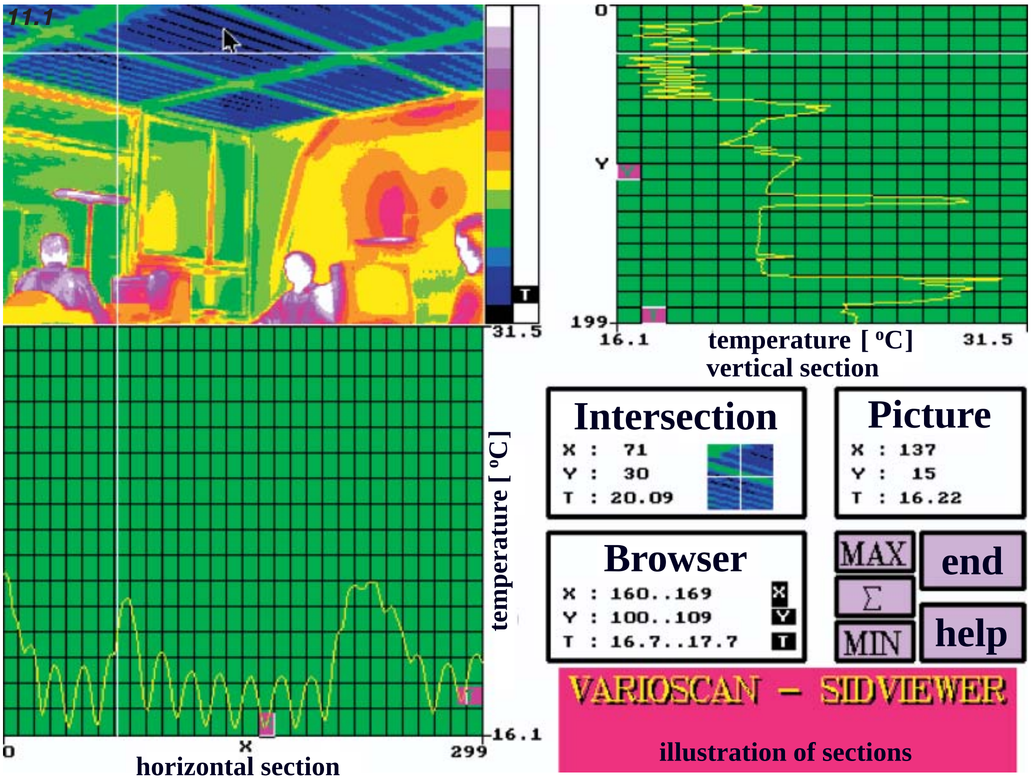
As an option, a perimeter heating system as well as a fresh air supply system could be operated in sequence (zero energy band 1K) with the chilled ceiling.

Since one of the characteristics of the REDEC chilled ceiling system is the large area coverage (as explained in the chapter Heat Radiation, page 11) it is recommended to allow in open plan offices for large control zones. If the office layout permits, zones between 70 and 130 m² can be planned.

Fig. 10.1 shows a schematic layout of standard equipment used on a control zone.

10.1





Commissioning

Pressure Testing

Like all hydraulic systems used in buildings, the chilled ceiling systems must be tested for possible leaks and tested to withstand the working pressure. These tests must be done prior to commissioning, observing the local rules and regulations.

Operational Testing

To achieve correct operationof the chilled ceiling, the system must be carefully vented. Furthermore, proof of water flow through all pipe work including the panel tubes is essential. The use of modern infra-red camera systems with image recording capacity provides a professional solution. The infra-red image print-out should be part of the commissioning manual. Fig 11.1 shows a typical thermal image including computerised evaluation of an active zone in operation.

Completed Installations

REDEC chilled ceilings in modern conference rooms

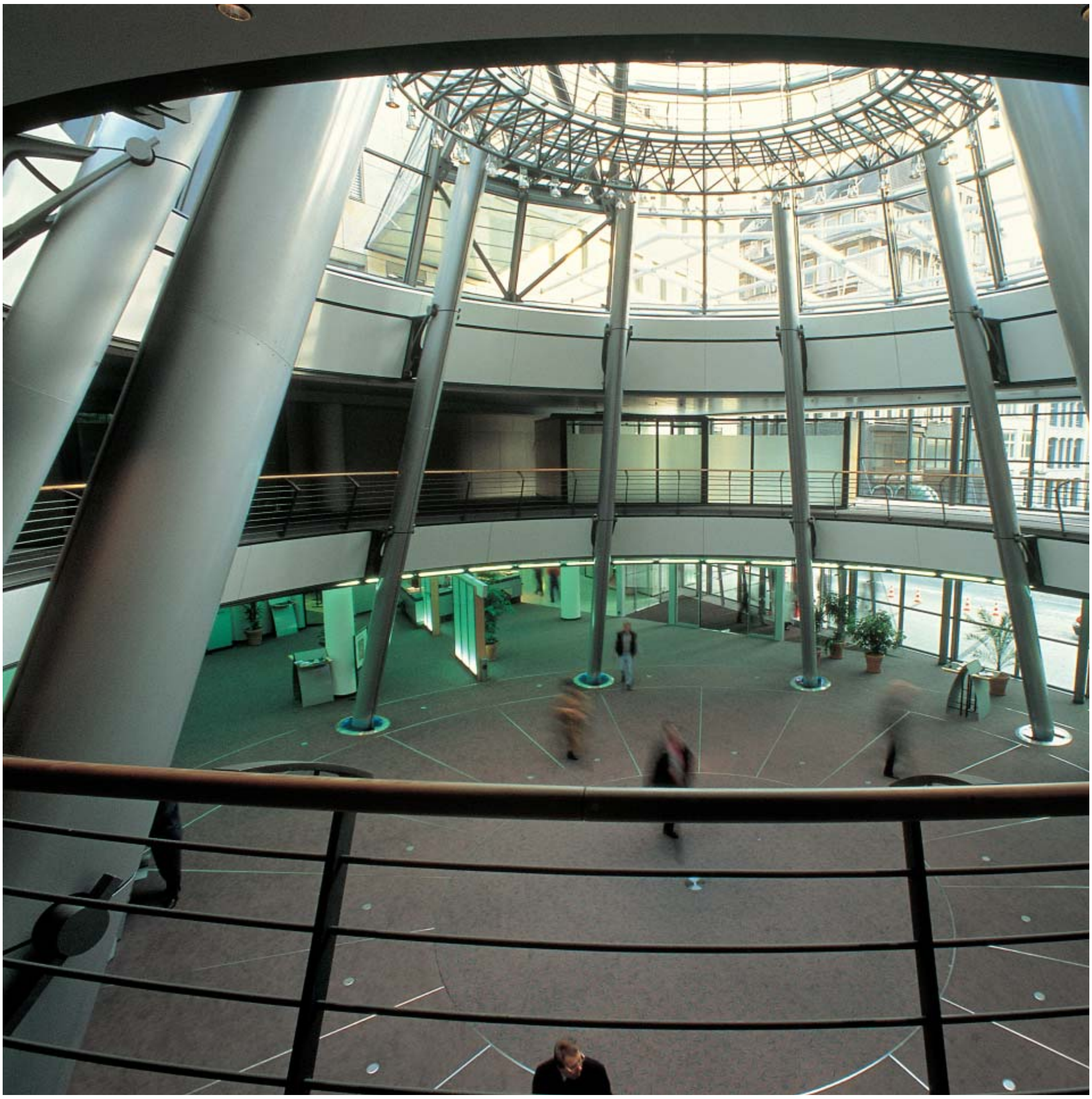
REDEC
chilled ceilings,
rectangular panels

room air cooling
with REDEC
chilled beams

REDEC chilled ceilings in conference rooms, with rimless air diffuser integrated in the panels

REDEC chilled ceiling technology, cassettes and circular segment panels

REDEC chilled ceilings in open plan offices



REDEC conical banister panels

REDEC chilled ceilings in cassette form

Specifications

Radiant chilled ceiling, type REDEC CBA-C, for the purpose of extracting sensible heat loads with radiant cooling up to 70% and convective cooling of 30%.

1. Selection Data

chilled water inlet temperature	________	°C
chilled water return temperature	________	°C
average chilled water temperature	________	°C
room air temperature	________	°C
room air humidity	________	%RH
room height	________	m
active temperature difference Δt_m (room air temp. - average water temp)	________	K
specific cooling capacity with reference to the active area in	________	W/m^2
chilled ceiling area	________	m^2
total ceiling area	________	m^2

2. Chilled Ceiling Panel

ceiling panel, powder coated, factory finished with heat conducting rails made of aluminium profiles, black anodised surfaces, with fitted precision copper tube quality according to DIN

The permanent bonding of the heat conducting rails to the ceiling panel is achieved by strictly observing the directions of the VHB procedure (very high bonding method). Through the use of special materials and manufacturing methods a permanent bonding and a highly efficient, optimal heat transfer is guaranteed.

2.1 Panel Material

steel sheet 0.7 mm thick, electrolytically zinc coated

alternative

aluminium sheet material thickness________ mm

2.2 Perforation

hole diameter 2.5 mm, 16% free area

alternative

perforated hole diameter ________ /________% free area

or non-perforated, flat

2.3 Surface Treatment

powder coated colour: RAL 9010 sfs (semi matt fine structure)

alternative

colour ______________________________

other colour coding ______________________________

2.4 Panel Dimensions

panel length ____________________ mm

panel width ____________________ mm

panel height ____________________ mm

2.5 Tubes

calibrated precision tubes acc. to DIN 1787, tube bendings produced on NC-machines

tube diameter ____________________ mm

alternative

calibrated mild steel tubes, zinc coated finish

tube diameter ____________________ mm

2.6 Acoustic Inlay

mineral fibre plate, 30 mm thick, weight 40 kg/m^3, wrapped and air tight sealed in plastic foil

alternative

thickness ________ mm weight ________ kg/m^3

alternative

black acoustic fleece, bonded between the heat conducting rails.

3. Ceiling Details

3.1 Ceiling Design

tartan grid lay-in system ____________ m^2

alternative

hidden hooking system ____________ m^2

or

special design system ____________ m^2

panels with studs 3 mm high

alternative

panels with studs 5 mm high

or

panels with sealing tape for gap distance 3 mm

or

special design with gap distance ________ mm

3.2 Checking dimensions and marking of centre lines in length and cross axis.

total ceiling area ________________ m^2

3.3 Support grid, adjustable in height, consisting of zinc coated steel- or alu profiles, fixed into the concrete ceiling using approved metal dowels and threaded rod minimum size M6

length ________________________ mm

The support grid must suit the geometry of the building.

total ceiling area ________________ m^2

3.4 Wall finish with single angle profile 20x20x2 mm

alternative

using a double angle profile 20x20x20x2 mm

or special wall connections ________ mm

total length ____________________ m

3.5 Connection on the facade with steel plate, colour specification identical with the ceiling. Integrated rails for blinds and curtains as well as an angle profile to support the ceiling panels
alternative
special design in acc. with the architectural demands
total length ______________________ m

3.6 Supply and installation of the inactive and specially shaped panels
total ceiling area ________________ m^2

3.7 Special equipment and adjustment

3.7.1 To fit the light fittings into the panels incl. cut-out and adjustment of support grid
dimension ________________ mm x ______________ mm
diameter up to _____________ mm

3.7.2 To fit the air diffusers into the panels incl. cut-out and adjustment of the support grid
dimension ________________ mm x ______________ mm
diameter up to _____________ mm

3.7.3 Cut-outs for:
- smoke detectors _______________ units
- sprinkler heads _______________ units
- detectors _______________ units
- loudspeakers and amplifiers _______________ units
- other equipment _______________ units

3.7.4 Special ceiling components and fitting costs for
- aprons
- partitions
- frieze
- other items ______________________________

3.8 Dispose of packing materials and return of surplus material

3.9 Finishing work, alignment of all panels after commissioning and final cleaning of ceiling
total ceiling area ________________ m^2

4. Hydraulic Equipment for each Zone

4.1 Supply of nipples, size 12 x $^1/_2$" BSPT to suit the hose push-on coupling on one side and the internal thread of the ball valve on the other side
total quantity ____________________ units
alternative
nipple size 10 x $^1/_2$" BSPT
total quantity ____________________ units
or
nipple size 15 x $^1/_2$" BSPT
total quantity ____________________ units

4.2 Supply of ball valves, size $^1/_2$", material brass nickel-plated with fitted nipples as described in 4.1 for the water inlet and water outlet branch
total quantity ____________________ units
Supply of ball valves, size $^1/_2$", material brass nickel-plated, with the possibility to fit an air vent/drain valve size $^1/_4$" directly onto the ball valve with fitted nipple as described in 4.1 for installation into the water outlet branch
total quantity ____________________ units

4.3 Supply and fitting of stainless steel all metal bellows type connecting hose, size DN 10, with push-on couplings at both ends, suitable for copper tube 12 mm dia, max. working pressure 9 bar, kv value 1,31 m^3/h
total quantity ______________ length ______________ mm
alternative
stainless steel all metal bellows type connecting hose, size DN 12, with push-on couplings at both ends suitable for copper tube 12 mm dia, max. working pressure 9 bar, kv value 1,95 m^3/h
total quantity ______________ length ______________ mm
or
low pressure hose DN 10, EPDM rubber material, braided with stainless steel wire, with push-on couplings at both ends, suitable for copper tube 12 mm dia, max. working pressure 10 bar, kv value 2,11 m^3/h
total quantity ______________ length ______________ mm
alternative
special material ___________ DN ___________
length ________________ mm with push-on couplings for
tube diameter ______________ mm
working pressure __________ bar
total quantity ______________ units

4.4 Filling and venting the chilled ceiling zones on condition that the main water installation is pressure tested and filled with clean water. The automatic re-filling of the system to working pressure must be safeguarded at all times
number of zones ________________________________

4.5 Commissioning, check on possible water leaks and proof of the perfect water circulation of all active areas with the aid of an infra-red camera system. The thermal images must be recorded and print-outs are part of the commissioning documents
chilled ceiling area ______________ m^2

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