



Barcol-Air Radiant Ceiling BRC

BENEFITS

- 100% reproducible 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 Barcol-Air radiant ceiling system type BRC provides the client and consultant, architect and the contractor with a highly flexible system.

Barcol-Air Radiant Ceiling system 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.

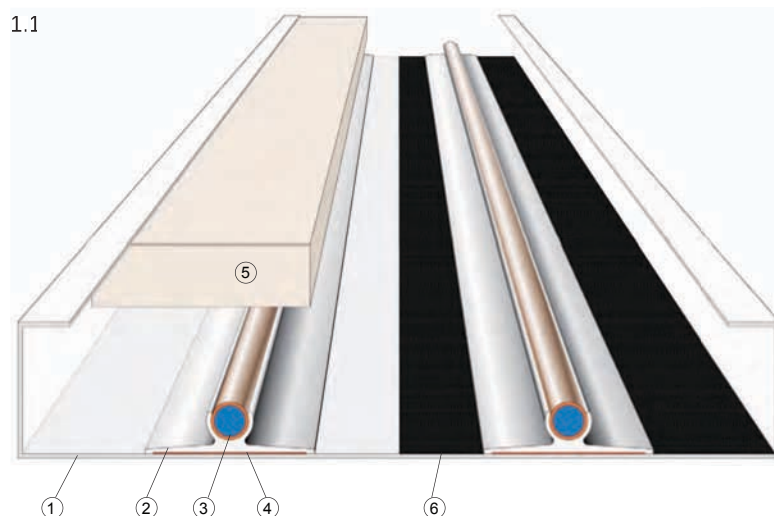
TYPICAL PANEL DESIGN

Metal Ceiling Panel fig 1.1 Pos. 1

The ceiling panel, normally manufactured from 0.027" thick zinc coated steel plate, powder coated approx. 80 µm thick to color code RAL9010 sfs (semi-matt fine structure finish), is perforated 0.098 inch dia. to provide 16 - 25% free area. Other colors, perforations and panel material are possible as supplied by most panel manufacturers.

Heat Conductive Permanent Bonding fig 1.1 Pos.4

The aluminum heat conducting rails are secured to the reverse side of the ceiling panel by a unique bonding process. The technique utilizes a special permanently elastic material which ensures a highly efficient heat transfer to the panel surface.



Heat Conducting Rail fig. 1.1 Pos. 2

The heat conducting rails are manufactured from high precision extruded aluminum profiles with a black anodized finish. The rails are specifically designed to accommodate the calibrated copper tube.

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.

Acoustic Inlay fig 1.1 Pos. 5

The acoustic inlay mineral fiber would be typically 1 1/5" thick with a density of 2 1/2 lb/sqft. The inlay is sealed in an air tight black plastic sheet, ensuring no fibers are being released. The chosen materials provide an optimum sound absorption. 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. (fig 1.1 Pos. 6)

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 tube rails is 5.9 inches with copper tube dia. 12 mm. The minimum distance from the edge of the panel is 2 inches. 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 accommodate a variety of mounting systems e.g. C-profile / Linear Grid / H-profile etc. Furthermore where the architectural design requires spaces between each panel, distance pads or space strips can be included to maintain uniformity of appearance.



THE ARCHITECTURAL DESIGN OF THE CEILING

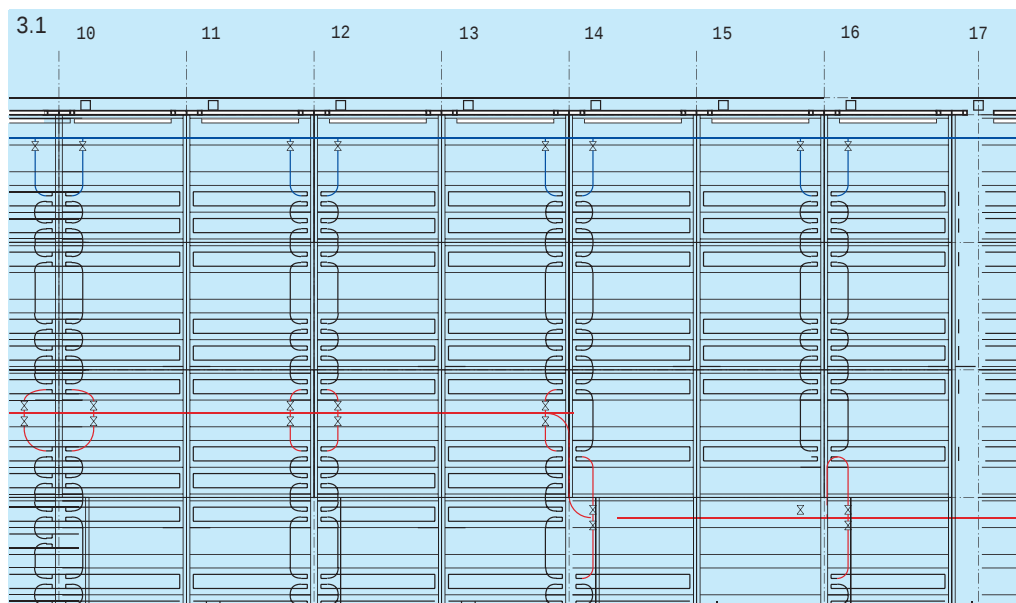
Almost any shape, preferably flat but also curved, can be chosen by the designers to accommodate the architectural requirements of the buildings.

fig. 3.1

A very typical design is shown in Fig. 3.1. Taking the window axis as a centerline, 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 places 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 accommodated.



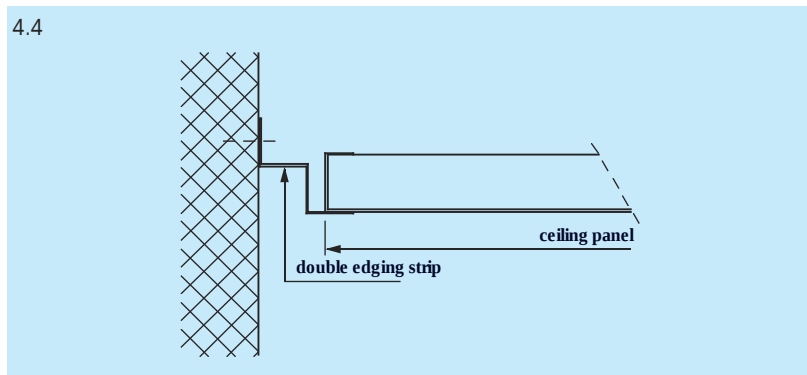
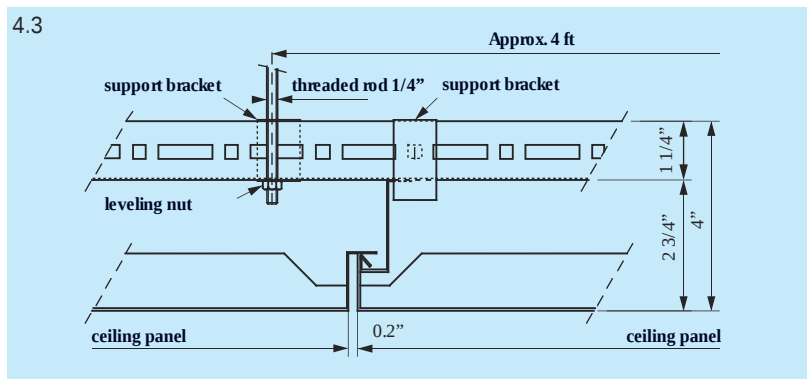
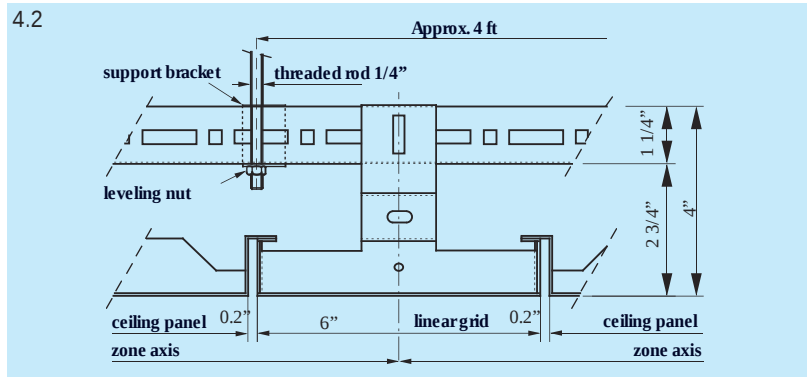


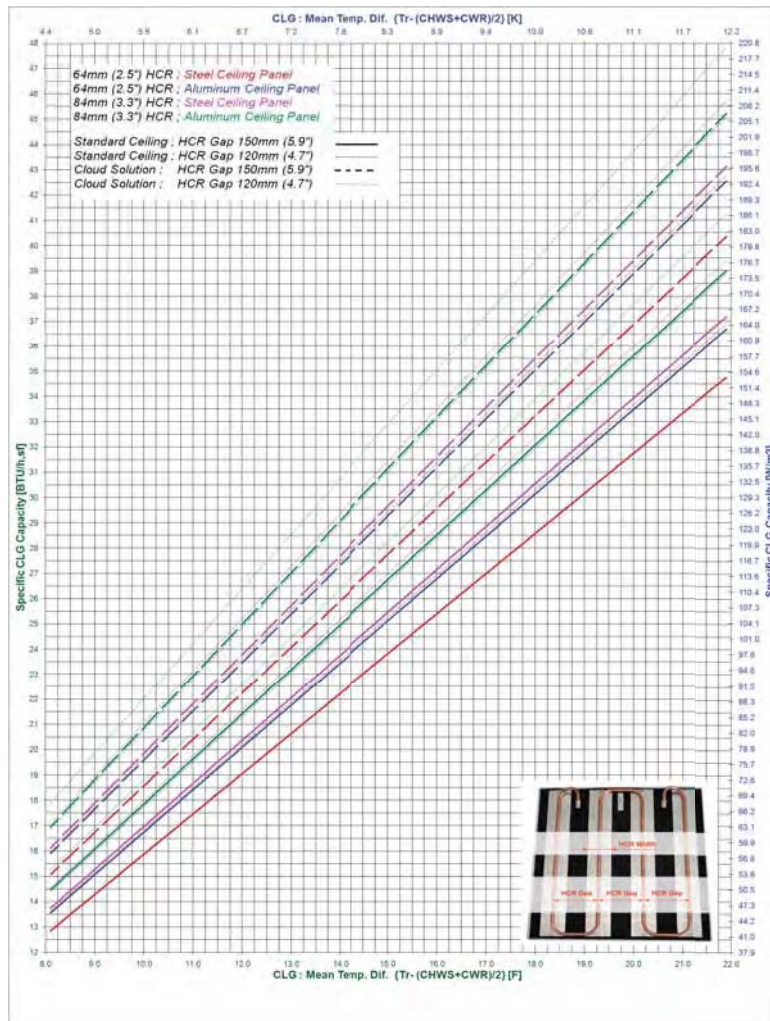
ACCESS TO THE CEILING VOID

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 Barcol-Air radiant 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 accommodates lighting equipment, double edging strips (see fig. 4.4) and loudspeakers, as well as supply air diffusers. Fire protection systems i.e. sprinkler and smoke detectors can also be integrated into the ceiling.





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 8'-10"
- 70% active area
- no fresh air supply from the ceiling
- symmetric 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 red line is valid for ceiling panels made of steel plate, 2.5" thick. The distance between the heat conducting rails is 5.9". The

green line is valid for panels made of aluminum, 3.3" thick. The distance between the heat conducting rails also at 5.9". The DIN test was carried out with heat conducting rails center to center 3.15". (sec. VF 99 K 24.1337). The standard cooling capacity can be increased to well above 63.4 Btuh/ft² and still fulfill the DIN-ISO- and SIA standards concerning comfort condition in the room, with the aid of additional equipment installed in the void.

HOW TO DETERMINE THE MEAN TEMPERATURE DIFFERENCE Δt_m :

$$\Delta t_m = (t_R - ((tw_i + tw_o) * 0.5))$$

Δt_m = mean temperature difference °F

t_R = room air temperature °F (dry bulb)

tw_i = temperature water inlet °F

tw_o = temperature water outlet °F

Whenever the difference between the room air- and the water outlet temperature is less than 11°F one has to use the logarithmic instead of the arithmetic average temperature difference.

$$\Delta t_m = (tw_o - tw_i) / \ln ((t_R - tw_i) / (t_R - tw_o))$$

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 asymmetric 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:

$$q = q_n * f_H$$

q = specific cooling capacity at the room ceiling height H

q_n = specific cooling capacity as shown in diagram fig 5.1

f_H = correction factor for different heights

Height ft:	8	9	10	11
Factor f_H :	1.043	1.000	0.950	0.907

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 façade
- 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 THROUGH A 12 MM DIA. COPPER TUBE

The excellent heat conduction from the surface of the active panels to the chilled water of the BRC system is based on a high internal heat conduction coefficient (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.

$$\Delta p_{TOT} = (\Delta p_1 \cdot n_p \cdot n_{HCR}) + \sum \Delta p_c$$

Δp_{tot} = total resistance of the circuit

Δp_1 = resistance of one heat conducting rail according to diagram 6.1

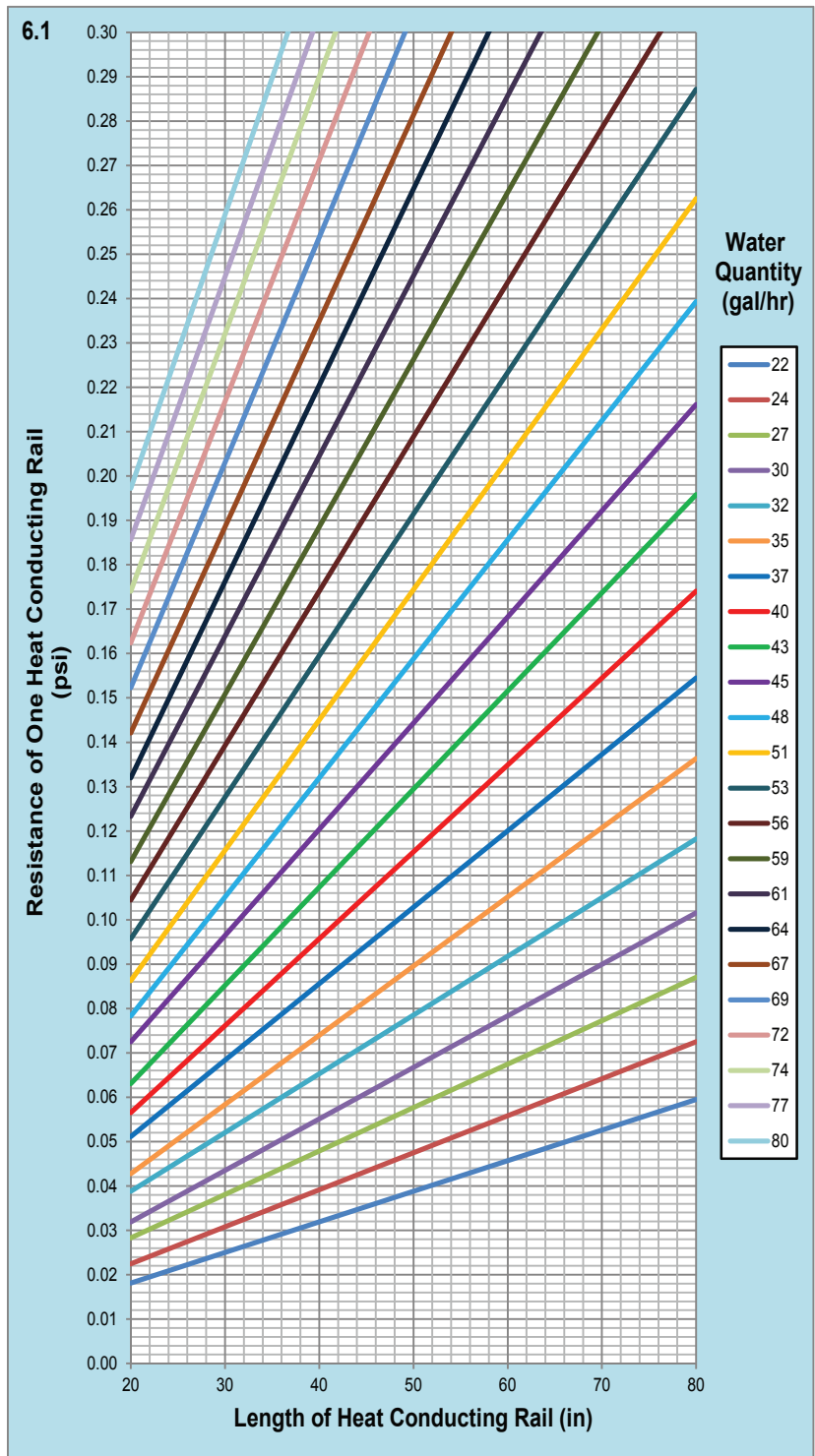
n_p = number of panels in series

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 18.49 gal/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 achieved, the specific cooling capacity must be corrected accordingly.



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

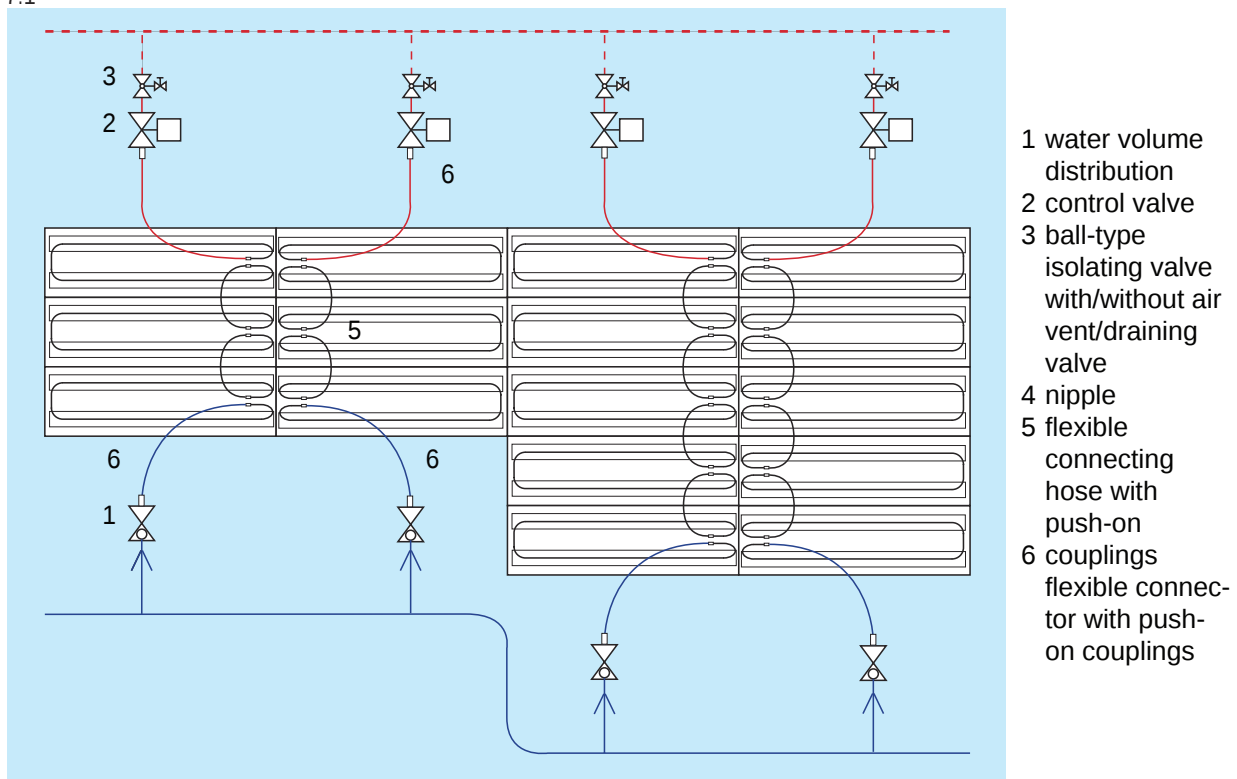
of a ball type valve on the water inlet and outlet branch, see Fig. 7.1 (Pos. 3 and 4). The advantages of this method are particularly useful during commissioning work or where alterations have to be made at a later date. During commissioning, the main water installation can be pressure and leak tested 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



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: 130.53 psi
 dimensions: DN 10 x 39.37 inches long
 Cv-value: 46.27 ft³/hr

HOW TO CALCULATE THE RESISTANCE OF ONE HOSE GIVEN:

Cv-value = 46.27 ft³/h, L= 39.27 inch,
 DN=10, bent 180°, water volume m = 21.13 gal/h

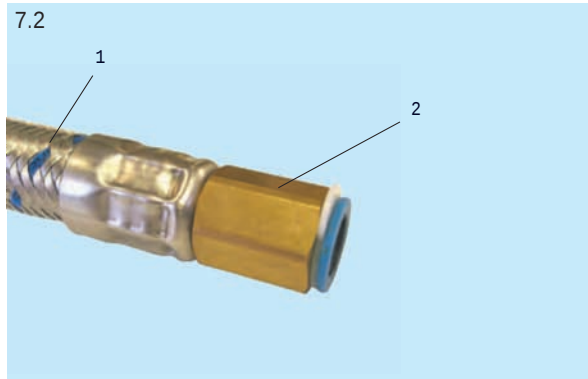
UNKNOWN:

Resistance Δp

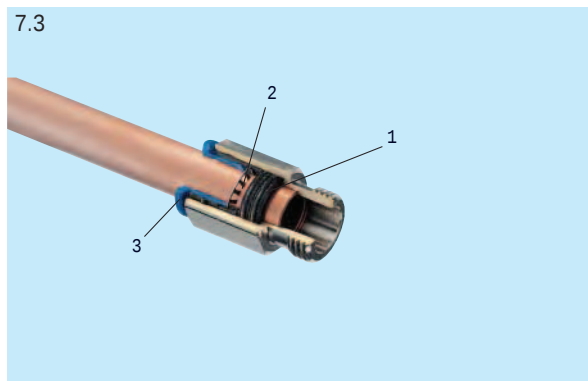
$$\begin{aligned}\Delta p &= (m/Cv)^2 \times 100 \\ &= (21.13/46.27)^2 \times 100 \\ &= 20.85 \text{ Pa}\end{aligned}$$

Fig. 7.3 shows the push-on coupling which has been specially designed for use with radiant 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 pipe-work has been drained.



1 metal flexible hose
 2 push on coupling



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

1/2" NPT

7.4



Ball type isolating valves, readily available on the market, can be used on the water inlet and outlet branch.

This type of ball valve is recommended for installation in the water outlet branch whereby the vent/drainage valve should be on the active panel side and not on the main water distribution side. Thus when required the active panels can be depressurized and drained.

5/8" OD,
ProPress

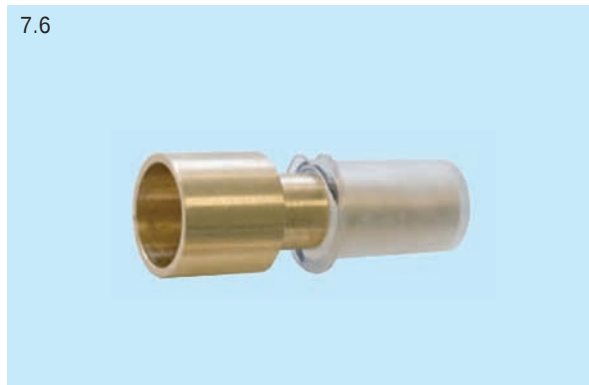
7.5



Barcol-Air brand nipples complete the integrated approach to efficient installation. The use of one piece, precision-machined brass ensures that the system will be tight and leak free and can be installed with minimum effort. The panel and hoses are designed to receive the 12 or 15 mm push-fit coupling of the flexible hoses at one end. Barcol Air can provide various solutions for connection to the piping. Please see Figures 7.4 through 7.6.

5/8" ID,
soldered

7.6



Our most popular option is the screw-in nipple, shown in Fig. 7.4., which can be tightened and screwed into the 1/2" NPT 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 room's 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.

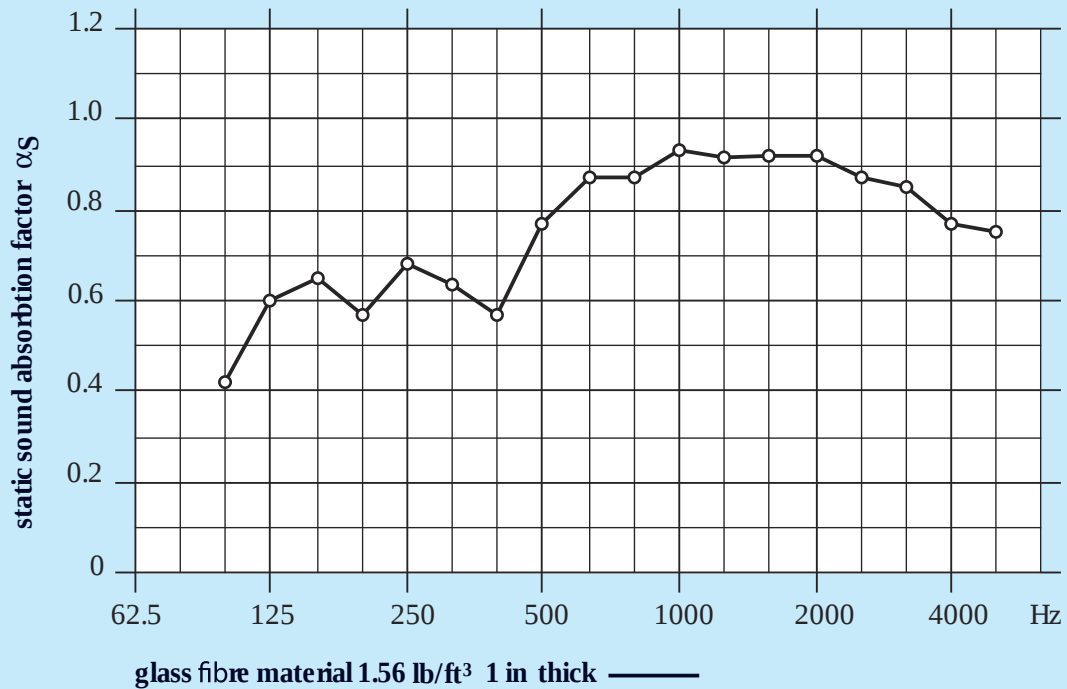
The diagram, Fig. 8.1, shows the sound absorption factor α_s as a function of the frequency for a standard ceiling panel of the following description

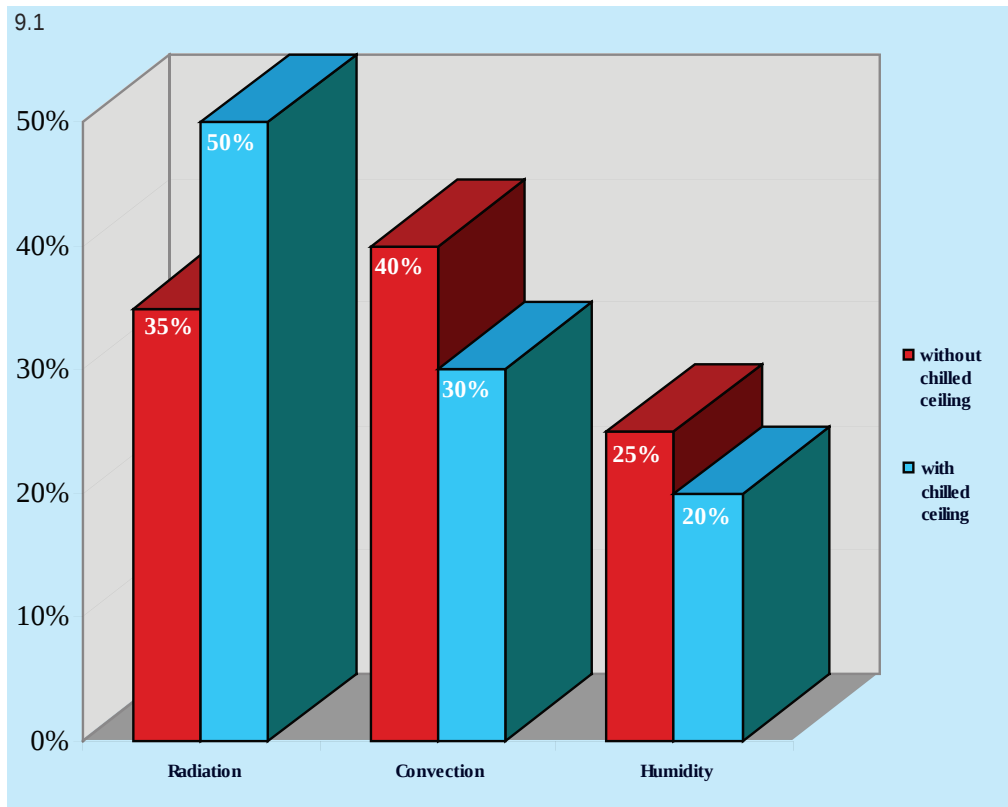
- steel panel, material 0.03 inches thick
- perforated with 0.1 inches dia holes, 16% free area
- sound absorbing inlay, glass fiber, material 1 inch thick, weight 1.56 lb/ft³

The main factors influencing the sound absorption are:

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

8.1





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 0.07 to 2.62×10^{-3} ft. For the total emitted radiation in a known specified area and time unit, the equation of Stefan Boltzman is applicable.

$$E = \epsilon \cdot C_s \cdot (T/100)^4$$

E = emitted radiant energy in Btu/ft²
 ϵ = emission ratio
 C_s = radiation coefficient of a black cube 0.1714 Btu/(h * ft² * °R⁴)
 T = absolute temperature in °R

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.

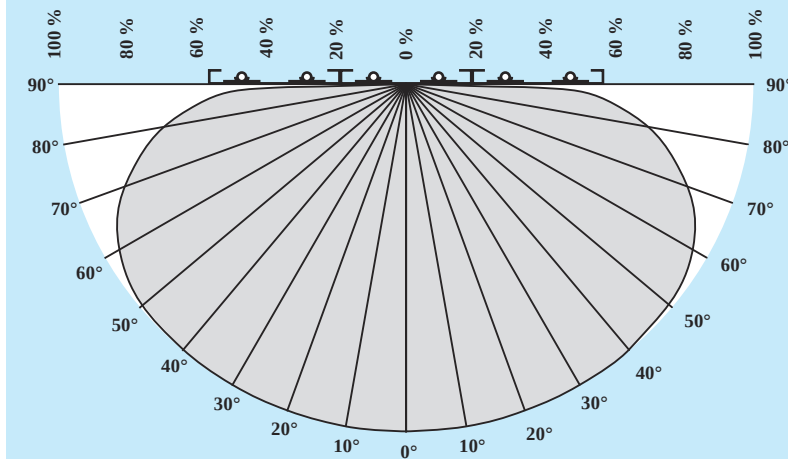
Fig. 9.3 shows the effect of heat radiation at different angles. A particular surface element absorbs radiant energy from all directions. The absorbed radiant energy is not affected up to an angle of 50°. At an angle of 75° the absorbed radiant energy is still 78% compared with the value at a right angle to the surface. The most important advantage of the BRC 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



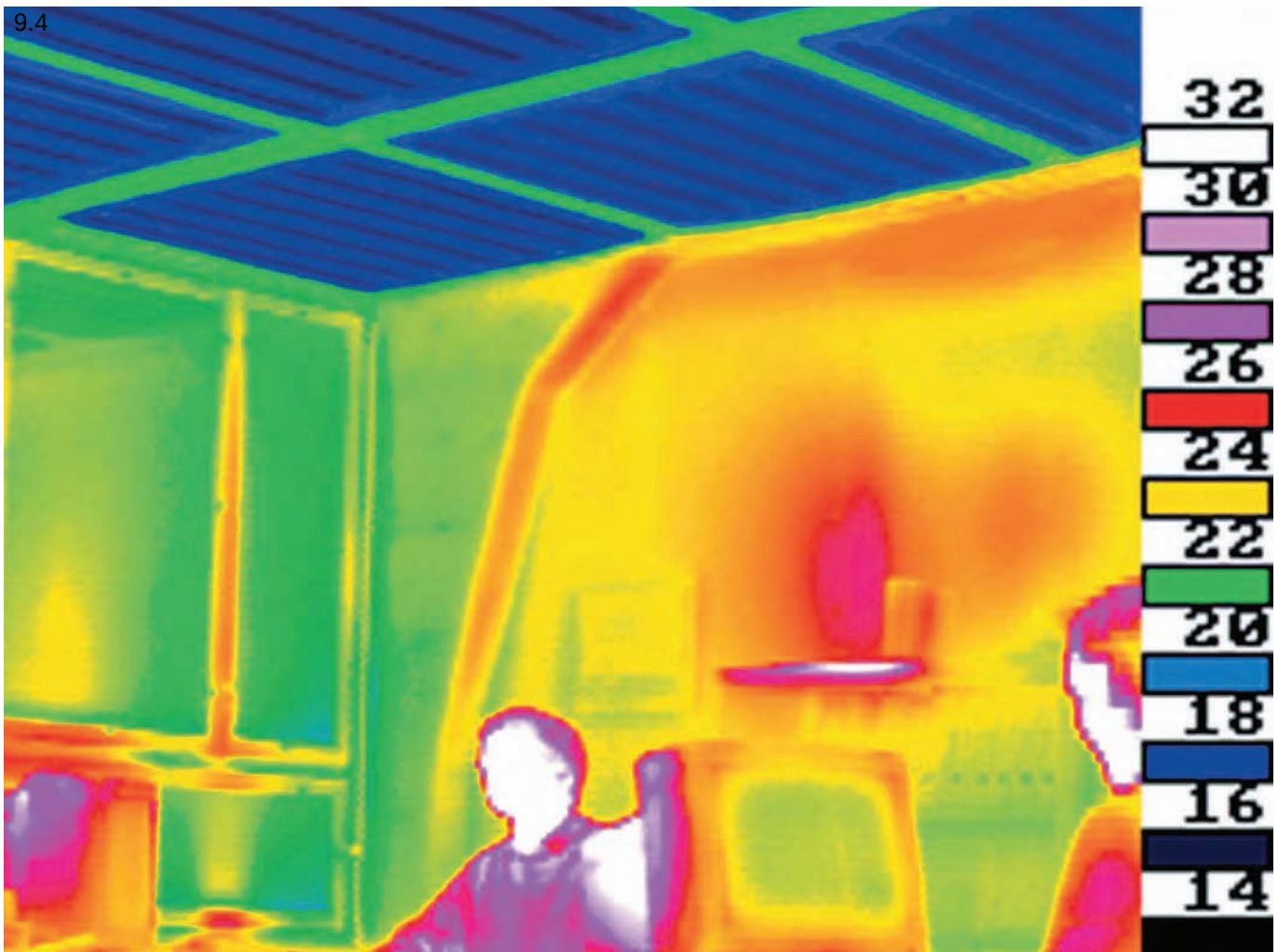
9.3



Due to the special design features of the BRC 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 ($\epsilon = 0.9 - 0.95$) ensures heat absorption 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.

9.4



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 BRC 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 1.8 °R 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 therefore 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 Cv values smaller than 35 ft³/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.

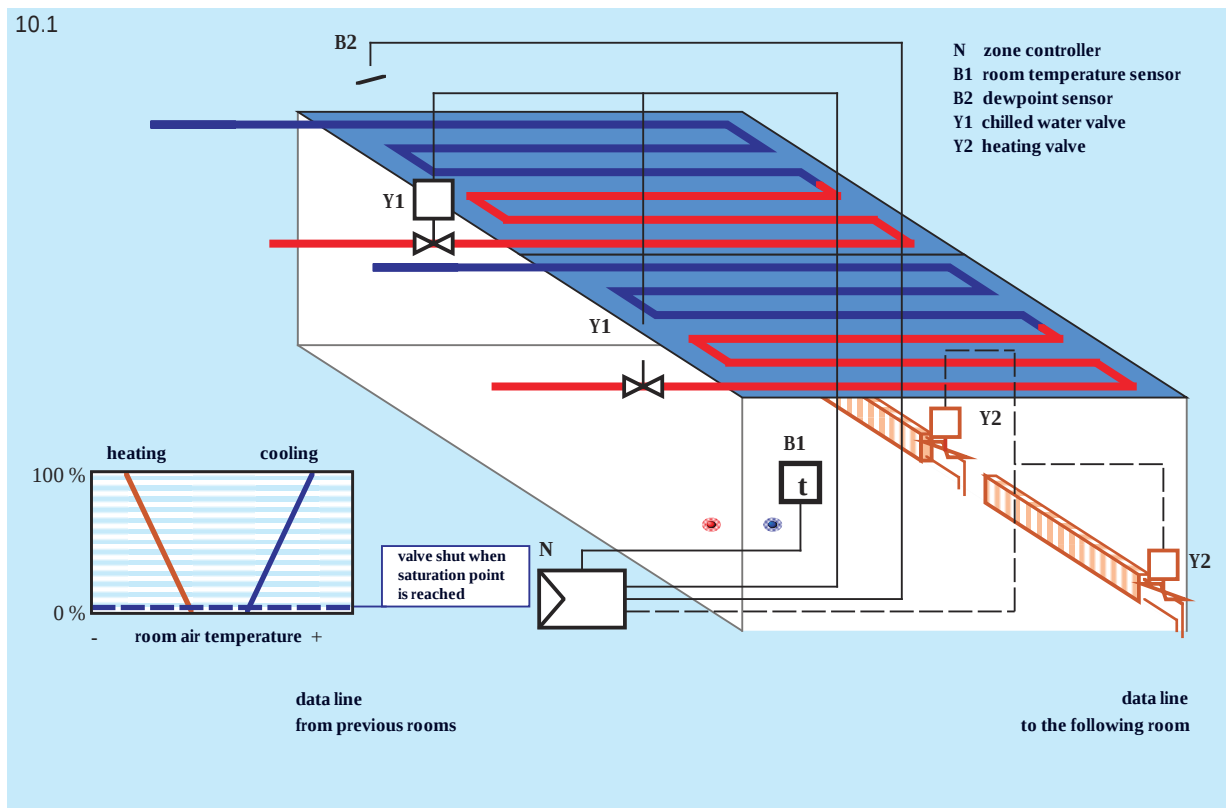
To eliminate any possibility of condensation, it is recommended to install a dew point sensor into each zone as a safety precaution. Prior to reaching critical saturation, the sensor would react and as a result the control valve would prohibit

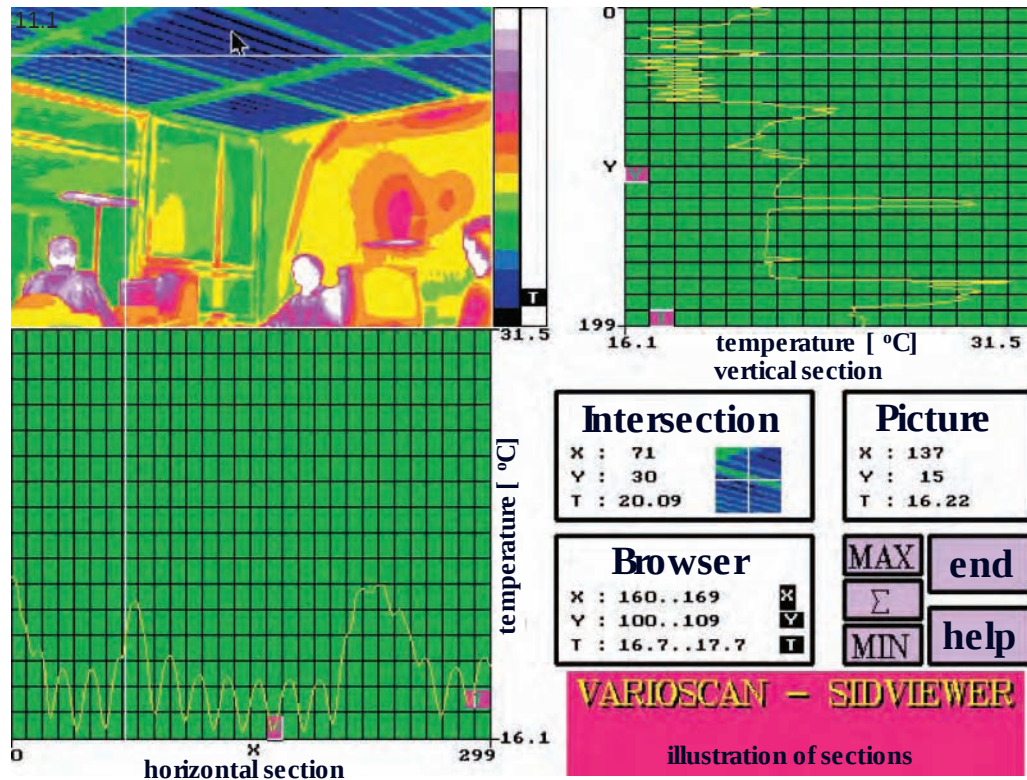
any water circulation in the zone.

As an option, a perimeter heating system as well as a fresh air supply system could be operated in sequence (zero energy band 1.8 °R) with the chilled ceiling.

Since one of the characteristics of the BRC 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 750 and 1400 ft² can be planned.

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





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 operation of 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 computerized evaluation of an active zone in operation.

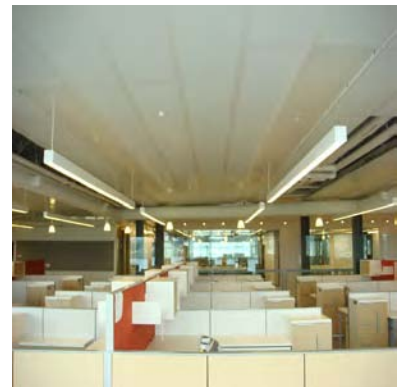
COMPLETED INSTALLATIONS



BRC chilled
ceilings in modern
conference rooms

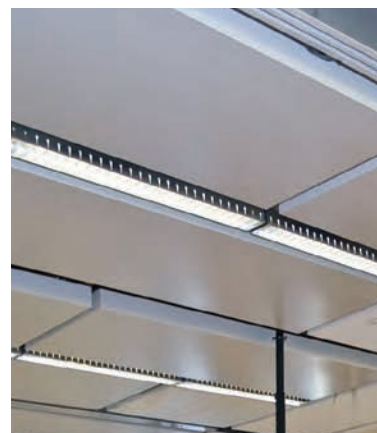


BRC chilled ceilings
and rectangular panels





Space cooling with Barcol-Air
radiant ceilings





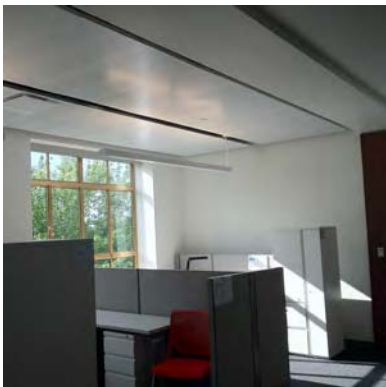
Barcol-Air radiant ceilings in conference rooms, with integrated rimless air diffuser in the panels



Barcol-Air radiant ceiling technology, cassettes and circular segment panels



Barcol-Air radiant
ceilings in offices





Barcol-Air conical
banister panels



BRC chilled ceilings
in cassette form



Contacts

Headquarters

Barcol-Air Ltd.
115 Hurley Road
Oxford, CT 06478
Phone: 203-262-9900
Fax: 203-262-9906
Email: info@barcolairusa.com
Website: www.barcolairusa.com

West Coast Office

Barcol-Air Ltd.
Georgetown Center, Building B
5963 Coreson Avenue South
Seattle, WA 98108

Website: www.barcolairusa.com



Your partner for radiant cooling and heating,
chilled beams and VAV systems.