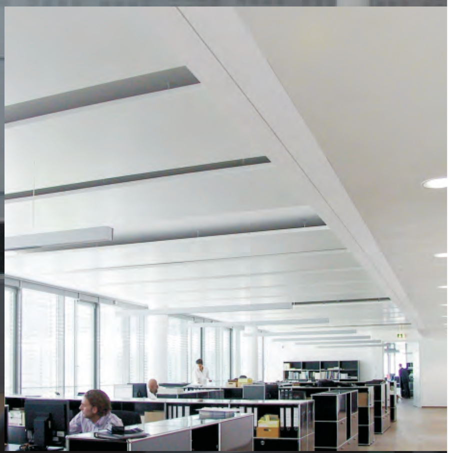

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RADIANT CONDITIONING SYSTEMS

WORKING WITH HEAT PUMPS

CONSIDERATIONS & BENEFITS

INNOVATION WITH STYLE

System Description

What is a radiant conditioning system and how does it work?

Radiant conditioning systems employ radiant heat transfer to cool or heat spaces in an energy efficient manner. They achieve this by indirect cooling/heating of the air and direct cooling/heating of the objects within the space.

A radiant conditioning system uses an array of radiant sails/panels mounted close to the ceiling. The lower surfaces of the panel are held at a lower or higher temperature than the surfaces of the room. Radiant exchange between the surfaces and the underside of the panels occurs as a result of these temperature differences. Space air is indirectly cooled/heated by convection across the room's surfaces.

What are the benefits of a radiant conditioning system?

Compared to competing systems which rely almost entirely on convection to directly condition space air, air movement is minimised along with the vertical temperature gradient.

Perhaps the major benefit of the radiant system is the reduction in space heat gains/losses resulting from the comfort achieved at higher space temperatures in cooling mode and lower space temperatures in heating mode.

How do these benefits arise?

The resultant or effective temperature felt by occupants is a combination of the space air temperature and the temperature of the surrounding surfaces. Resultant temperature is used as a true measure of the degree of comfort experienced. In cooling mode, the surfaces, and particularly the ceiling, are at a considerably lower temperature than the air and the same resultant temperature (comfort level) is experienced at higher space air temperatures than for competing convective systems. This higher space air temperature, typically 2°C, gives rise to a reduction of 20% in the cooling load.

During the heating season a radiant conditioning system allows the same degree of comfort to be maintained at space temperatures some 2 to 3°C lower than with convective systems. This gives rise to reductions in the heating load of 10 to 15%.

What variety of radiant conditioning systems are available?

Two distinct types of radiant system can be utilised depending on the space usage and cooling/heating requirement. A year round conditioning system may be employed capable of providing cooling and heating from the same panels. Alternatively, where cooling is not required, or even allowed, a heating only system can be used.

The two systems should be treated differently; a year round conditioning system benefits from the use of SPC Thermasail radiant sails which are typically mounted below the level of an exposed soffit. A heating only system would normally use SPC Thermatile radiant panels fitted within a ceiling grid.

System Description

What is a radiant sail and how does it differ from a panel?

A radiant sail shares many of the features of a radiant panel but is suspended below the ceiling with its upper face exposed to room air at high level and its lower radiating face exposed to the surfaces of the room. A radiant panel is fitted within the grid of a false ceiling with its upper surface insulated and only its lower radiating surface exposed to the space.

What are the benefits of a radiant sail compared to a radiant panel?

Radiant sails are used in systems which take advantage of the sail's features to provide space cooling. As the cool upper surface of the sail is exposed to room air at a high level there is an additional output benefit achieved as a result of the convection of warm air along the upper face of the panel and this cooled air spilling down over the edges into the space below. Cooling outputs of around 115W/m2 are typically achieved by sails, well in excess of that available from a conventional chilled ceiling where the panels are fitted in a ceiling grid.

As the sail is free hanging rather than constrained by the size of the ceiling grid the range of shapes and sizes available is almost limitless.

What type of chilled water/hot water source is best suited to a radiant conditioning system?

When used for cooling, radiant sails will occupy a large percentage of the available ceiling space. Chilled water temperatures must be sufficiently high so as to prevent condensation on the underside thus limiting the cooling capacity. When these conditioning sails are used in heating mode the available surface area will be in excess of that required when using a conventional high temperature water source. Accordingly, the hot water flow temperature will be decreased to match the load requirements.

Reversible heat pumps match the requirement perfectly due to their particular characteristics. When the delivery temperature of a heat pump in heating mode is reduced its Coefficient of Performance and efficiency increases. Conversely, in cooling mode, the efficiency of the heat pump increases as the flow temperature increases. These peculiarities of heat pumps ideally match the peculiarities of the radiant conditioning sails. The adoption of the renewable technology operating at its optimum efficiency in combination with the energy savings associated with radiant systems provides the most energy efficient conditioning system available.

Design Criteria

What outside air conditions should be used in the system design?

Standard design conditions for outside air apply to radiant systems and do not differ from other conditioning systems. Wherever possible local weather data should be used.

What internal space temperatures should be used?

A radiant system benefits from a higher resultant air temperature in the summer meaning that the internal space temperature used as the design figure can be 2°C higher than for convective systems i.e. a space air temperature of 26°C radiantly cooled will be equally comfortable as a space air temperature of 24°C maintained by a convective system.

Similarly, the winter internal space temperature can be held at a temperature as much as 3°C lower than a conventional heating system with no lack of comfort i.e. 19°C will feel as comfortable as 22°C.

How is the summer cooling load and winter heating load calculated?

The calculation for heating and cooling loads is performed in the same way as for any other system but the modified space air temperatures shown above should be used. When these modified values are used then both heating and cooling loads will be markedly reduced from those associated with a conventional system.

What water flow and return temperatures should be used?

In cooling mode the water flow temperature should be arranged to be no lower than the dewpoint temperature of the space air. This will be achieved with flow temperatures of no less than 14°C and a return temperature of between 3 and 5°C above this.

In heating mode the flow temperature to the panels should be selected to suit the surface area of the panel and the heating load. In a year round conditioning system the total panel area will always be determined by the cooling rather than heating requirements.

If radiant panels are used in a heating only application then the size of panels will be determined by the heating load and a higher water flow temperature should be selected. A flow temperature of 65°C and return of 60°C is achievable using new high temperature heat pumps and these values should ideally be used to size the panels.

How should outside air be introduced?

Building regulations stipulate the ventilation required of a particular type of building. When radiant sails are used for cooling the space it is important that the ingress of outside air is controlled and that the outside air is pre-conditioned. In cooling mode sails operate against elevated chilled water temperatures to prevent condensation forming and accordingly they only provide sensible cooling. Outside air should be provided via a dedicated primary air unit which should be capable of reducing the dewpoint temperature of the supply air to around 12°C. Opening windows to provide ventilation is not acceptable in humid environments.

Design Criteria

How are the sails/panels sized?

For a full conditioning system the area of exposed sail required is simply calculated by dividing the cooling load by the output per square metre of panel. The latter will vary depending upon the water and air temperatures but typically a value of around 115W/m2 is suitable. Having calculated the total area required the number, size and shape of individual sails can be determined.

For a heating only system the area of panel required is determined by dividing the heat load by the output per square metre of panel. Again this varies but a good approximation for panels suited to high temperature heat pumps and fitted in a ceiling grid is 420W/m2. If using conventional boilers as the heat source then this figure rises to around 500W/m2.

How are the Heat Pumps sized?

For a full year round conditioning system a reversible heat pump should be selected. This will allow the generation of both hot and cold water depending upon the season. For a heating only application a high temperature heat pump designed to provide only hot water may be used.

The capacity of the heat pump should be at least equal to the cooling/heating load at the flow and return water temperatures used as well as the outside air temperature used for the design (applies particularly to air source heat pumps).

If the cooling or heating load is in excess of the capacity of a single heat pump then multiple units should be used under a common control.

Should the Heat Pump be ground/water source or air source?

The source of heat does not affect the operation of the radiant system and heat can be drawn from any convenient source.

Ground/water source heat pumps benefit from slightly higher efficiencies and will be more stable against varying outdoor conditions. Air source heat pumps are far simpler to install and the capital expenditure is significantly lower.

Are there any other requirements for the system?

When using heat pumps it is important to design a system which has sufficient volume to ensure stable operation and provide sufficient inertia for the defrost cycles of the heat pump in winter so as not to affect the temperature of the space.

All heat pumps need a specified system volume and this should be checked against the actual system volume. Buffer tanks are regularly used to bolster system volume and to link multiple units. Well designed systems will use the buffer tank to couple the primary heat pump side to the secondary emitter side of the system to ensure stable operation and simple control.

Controls

What type of control best suits sails/panels?

The rate of cooling/heating provided by the sails/panels is directly proportional to the temperature difference between the panel surface and the temperature of the surfaces within the space. The output varies almost directly with this temperature difference and hence modulating control of the output can easily be achieved by modulating the water delivery temperature. Furthermore, the sails/panels can be zoned to provide the necessary modularity and also to provide individual occupant control. These control features allow energy efficiency points to be accumulated and BREEAM points to be gained.

How should the heat pumps be controlled?

If multiple heat pump units are used in combination in order to provide the required total output then they should be controlled by a single controller designed to stage their performance. Multi-unit controllers are available with heat pumps and these allow the group of heat pump to operate at their most efficient.

The water flow temperature from the heat pump can be varied to suit the cooling/heating load. When sails are used for cooling then the chilled water flow temperature must be maintained at a level so that the surface temperatures of the sail are above the dewpoint temperature of the space air. This will be assured if the flow temperature is limited to a minimum of 14°C. As the cooling load decreases then the flow temperature can be allowed to increase.

When used in heating only applications weather compensation, which will normally be incorporated in the heat pump controller, can be used to ensure that the heat pump operates at its most efficient level. Weather compensation depends upon an in-built algorithm to reduce the water delivery temperature when the outside air temperature increases and the heating load is reduced. At reduced flow temperatures the heat pump will provide a higher COP as the energy drawn is reduced.

Both the heat pumps and sails/panels can be controlled by a central BMS. The central control can then be used to control the operating mode of the heat pumps (cooling/heating), the heat pump delivery temperatures and the operation of any zone valves incorporated in the sail/panel circuits.

System Acoustics

How does the radiant system minimise sound pressure levels?

Unlike convective systems, a radiant system does not involve air movement. Accordingly, there is no noise generation either from fans directly in the space or from grilles and diffusers supplying air from a ducted system.

In addition to the lack of noise generation provided by the system a radiant sail/panel can be provided with a thin blanket of acoustic insulation on its upper side. In conjunction with the acoustic lining perforations are made in the lower surface of the panel to provide significant acoustic absorption.

System Aesthetics

What will the sails/panels look like?

Heating only panels would normally be fitted within a conventional ceiling grid and would be sized accordingly. The shape and size of a radiant sail, however, is not subject to the same constraints.

While sails can be of a standard rectangular pattern and painted white should this suit the features of the building, there is no need to limit your imagination. Colours are limitless and the images below give ideas as to the bespoke shapes which can be generated.

Unlike panels, which sit within the T bars of the ceiling grid, sails will have a finished edge to disguise the internal sandwich construction and provide a pleasing outlook when viewed from below. If an application demands it then holes can be cut into the sails for light fittings or the inclusion of other services to make the sails multi-functional.

Environmental Considerations

When using heat pumps to generate chilled/warm water the installation will be taking advantage of renewable energy from the air, ground or water. The only carbon footprint of the system will result from the energy input in the form of grid electricity required to operate the heat pump. A well designed system will operate at a COP of between 3 and 4 i.e. 3 to 4 times the rate of cooling/heating is provided compared to the rate at which electrical energy is consumed.

The radiant sails/panels rely on chilled or warm water to be circulated through the serpentine of pipes on their upper face. Only water is circulated through the occupied space. Unlike VRF systems the refrigerant in the system is restricted to a low mass circulating only through the heat pump itself located outside the space. The F gas regulations for servicing of equipment are minimised due to the low refrigerant mass.

The ability to provide a system which can be zone controlled and weather compensated increases the energy efficiency of the system by reducing overcooling and overheating of spaces and closer matching of the load to the system output. Such considerations are granted extra points in the BREEAM system of rating buildings for energy efficiency.

Sails/panels contain very low volumes of water and as such are highly responsive allowing the radiating surface to reach its design temperature very quickly. This rapid response means that the cooling/heating is available when required and there are no long and inefficient cool down or heat up periods.

Installation and Maintenance

Radiant sails and panels benefit from simple installation procedures; panels are simply fitted into ceiling grids and suspended by lightweight wire hangers. Sails are anchored to the soffit using either lightweight wires or rods depending upon the size/weight of the sail.

All the pipework for the sail/panel system is standard plumbing pipework; there is no on site refrigeration piping to be undertaken. Flexible hoses are often used as the final connection to the sails/panels allowing wide pipework tolerances.

Having no moving parts maintenance of the panels is restricted to a regular wipe down with a cloth. The hydronic system is subject to the treatments and maintenance common to all water systems; there are no special requirements.

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