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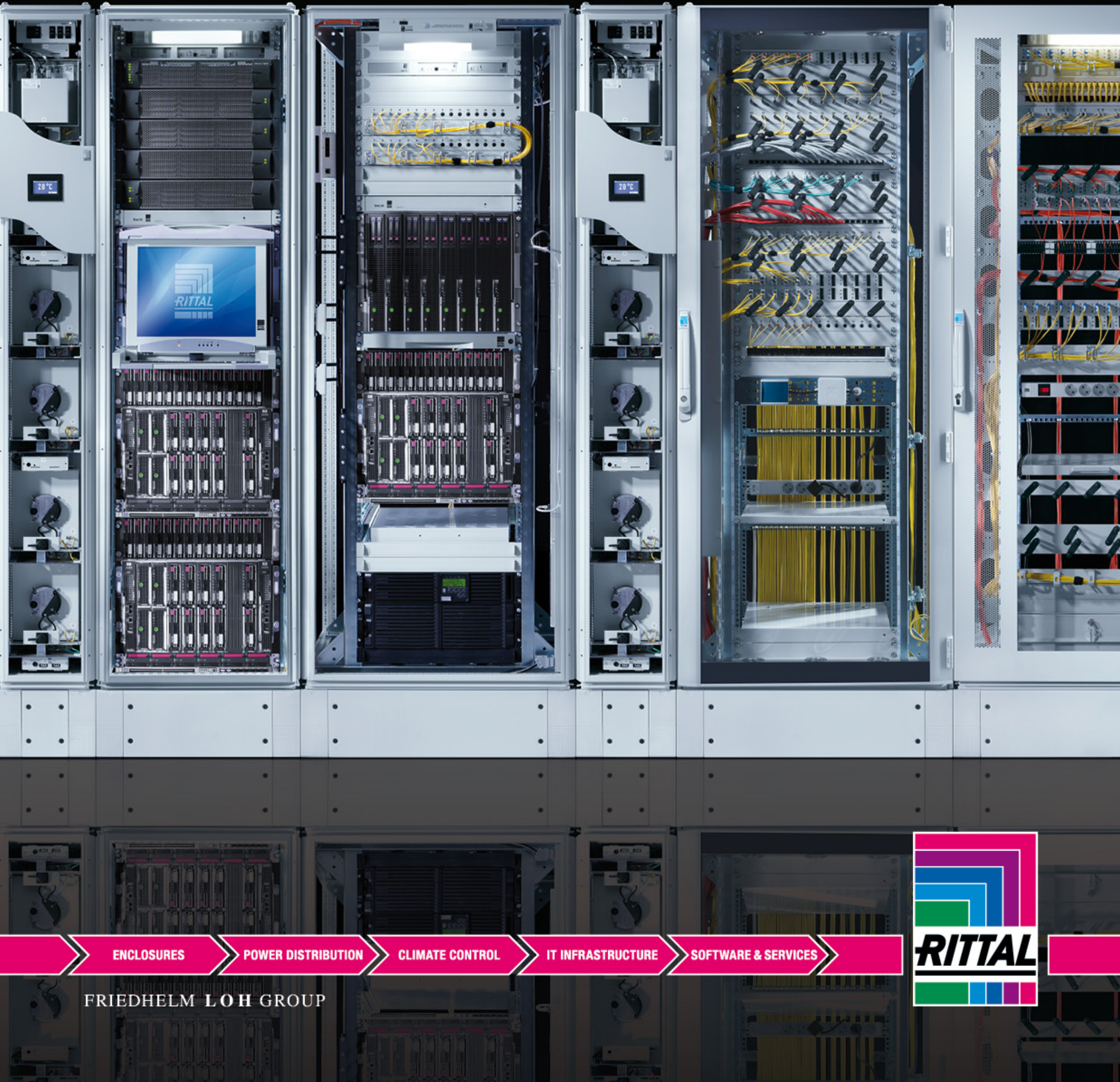
White Paper – Row-based cooling with the LCP Passive



ENCLOSURES | POWER DISTRIBUTION | CLIMATE CONTROL | IT INFRASTRUCTURE | SOFTWARE & SERVICES

FRIEDHELM LOH GROUP

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Executive summary

In modern data centres, the infrastructure accounts for half of all electricity consumption, with the lion's share being attributable to cooling. The TopTherm LCP Passive from Rittal is an energy-efficient solution that is suitable for both installation in new data centres, and for retrofitting. As there are no fans installed in the LCP Passive, and air from the server fans is routed through the LCP heat exchanger instead, certain requirements concerning the infrastructure and the ambient conditions must be met. The server fans must be capable of overcoming airside power loss by the heat exchanger in the LCP Passive. This must be taken into account and clarified at the general planning stage. Furthermore, there must be no strong opposing air flows outside of the rack contrary to the direction of the server fans. Sealing and air routing inside the rack are required to selectively route the waste server air via the LCP Passive and prevent hot spots.
As the LCP Passive does not have its own controller, monitoring system or fans, it does not consume any electrical power and therefore does not need to be supplied with voltage. This makes the LCP Passive particularly efficient, and significantly reduces power consumption within the data centre.

Introduction

In a modern office environment, data centres are at the heart of the IT system. This is where all important information converges and is stored. The ambient air in the racks must be climate-controlled to prevent the failure of key components and servers in the data centre. Otherwise, the components would overheat and suffer considerable damage, which apart from causing data loss, would also cause work to grind to a halt.

As the computing capacity of servers grows, so too do the requirements placed on a cooling solution. As well as distributing high heat losses from servers, a climate control unit should also consume the minimum possible energy and be environmentally friendly.

Rittal's **L**iquid **C**ooling **P**ackage (LCP) offers a climate control solution which uses cold water to cool down the air inside the data centre. The heat is transferred to the water via an air/water heat exchanger and dissipated from the data centre. Pipes transport the heated water to a recooler which cool it down and route it back to the LCP.

Objectives and requirements

These days, the manufacturers of servers and IT equipment try to pack as much capacity as possible into the smallest available space. However, as computing power grows, so too does the heat loss from servers, and this must be dissipated from the enclosure using climate control equipment. At the same time, however, electricity consumption is also growing. A comparison between the electricity consumed by servers (the IT system itself) and that consumed by the infrastructure indicates that only half of the energy consumed by an entire data centre is attributable to the servers. The other half is therefore attributable to the infrastructure in the form of power distribution and backup, cooling, lighting etc. (Figure 1).

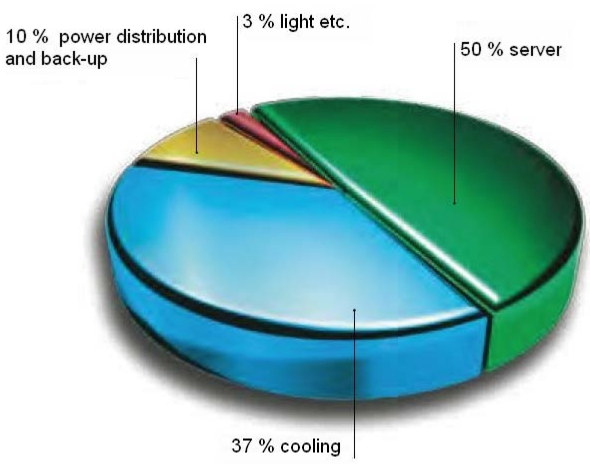

Figure 1: Energy consumption of data centres

Most of the energy consumed by the infrastructure is required for cooling. On average, data centre cooling accounts for 37% of the total electricity consumption.

According to the German Environment Agency, the electricity consumed by data centres in Germany totalled 10.1 TWh in 2008[1]. This translates into 3,737 TWh used to cool Germany's data centres in 2008.

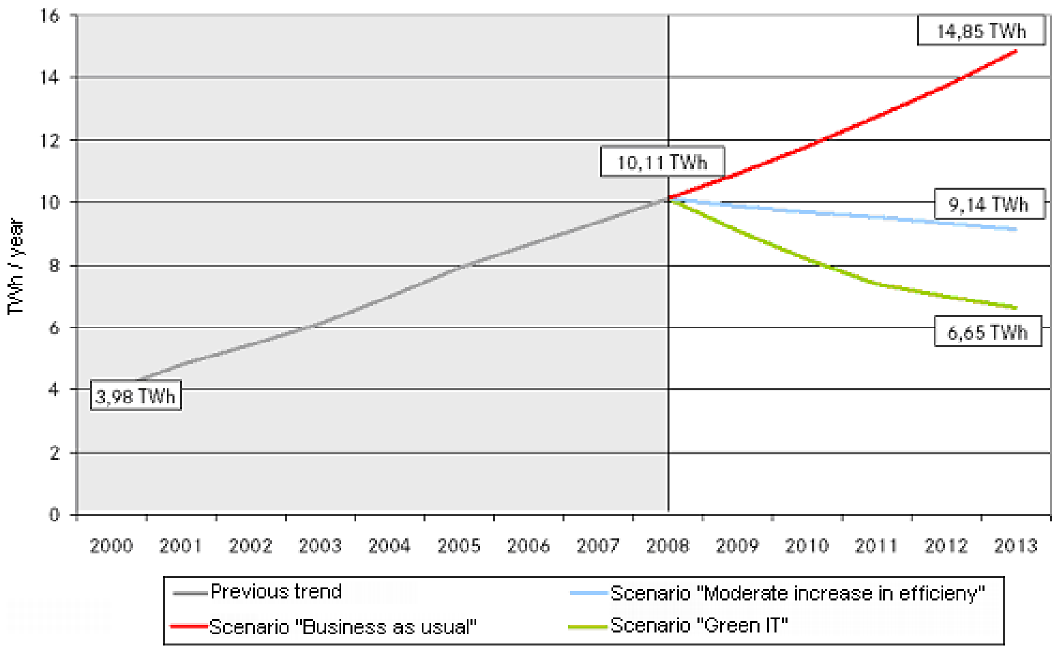

Figure 2: Electricity consumption by Germany's data centres

Source: Umweltbundesamt (Federal Environment Agency)

[1] Cf. Bundesumweltamt (Federal Environment Agency), page8

Whereas electricity consumption has risen sharply in recent years, a growing number of manufacturers are now focusing their attention on efficient designs and minimal power consumption.

Figure 2 illustrates a range of possible scenarios. In particular, the scenarios of “moderate efficiency increase" and "green IT" represent the ambitions of many manufacturers. Without more efficient equipment and solutions, power supply and distribution bottlenecks can occur. In the area of cooling, too, current developments will soon reach their limitations, and it will no longer be possible to completely dissipate heat losses with inefficient climate control equipment. In the interests of corporate social responsibility, it should be the aim of every company to save energy and thus help to reduce environmental pollution[2].

In particular, planning is a key factor in the energy-efficient data centre. As well as selecting the most energy-saving components for IT equipment, power distribution, cooling etc., planners should also focus on the correct positioning of the enclosures. A well-planned infrastructure that leaves space for expansion and configuration at a later date may be particularly advantageous when it comes to cooling, since air turbulence can cause major losses.

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[2] Cf. Bitkom

The Liquid Cooling Package

The Liquid Cooling Package (LCP) from Rittal is a modular cooling concept that can be flexibly adapted to suit the requirements of any data centre. An LCP is integrated into a row of enclosures with the racks, and uses a variety of techniques to cool the servers in the enclosures, depending on the LCP variant. The benefit of the LCP is that all 42 U in a 2000 mm high rack is available for use. Cold air is distributed evenly across the full height of the enclosure, thereby ensuring even cooling of the servers.
The LCPs are connected to two supply channels. Firstly, an LCP must be supplied with electricity, and secondly, it must be connected to a refrigerant circuit. Water is generally used as the refrigerant. After being heated in the LCP, it is routed to a recooler and cooled down. After the cooling process, the water can be reused by the LCP to cool the air.
The LCP units may also be connected to a network, allowing current measurements and status data (such as fan speeds, temperatures etc.) to be accessed from a PC workstation, and parameters to be set. These parameters are likewise accessible via an optional touchscreen display on the device itself.

The LCP rack

The standard LCP version is the Rittal TopTherm LCP Rack. It builds its own air circuit inside the enclosure and thus cools the servers (Figure 3). The hot air is drawn in at the rear of the servers by the fans, cooled down in the LCP, and blasted back into the rack at the front of the servers. In turn, the servers use this cold air to cool their components.
Redundant cooling may be installed with the LCP Rack to support high-MTBF and increase operational reliability. In addition to the redundant configuration with two LCP racks, Rittal also offers an LCP variant entitled “Rittal TopTherm LCP T3+” which supports a redundant configuration without the need for an additional device. Two supply channels for electricity and refrigerant may be connected to the LCP T3+. If one channel should fail, the other can take over the full load.

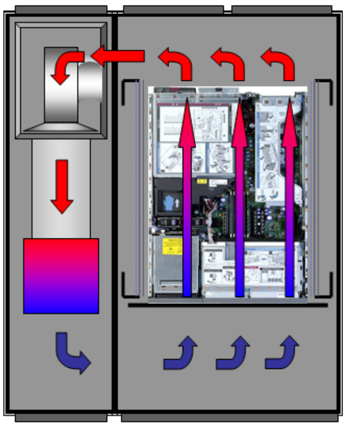

Figure 3: Function of the LCP rack (viewed from above)

The LCP Inline

The Rittal TopTherm LCP Inline is likewise positioned in series with the racks. Unlike the LCP Rack, the inline version cools the ambient air throughout the entire data centre, but remains independent from the infrastructure and rack configuration. To this end, the hot air is drawn in on one side, cooled down, and blasted out again on the other side. Figure 4 shows how the LCP Inline works. It is positioned between the racks and draws in the hot air expelled by the servers. This air is cooled down in the LCP and routed to the cold air side of the racks, where the cooled air is available to the servers for cooling their components.

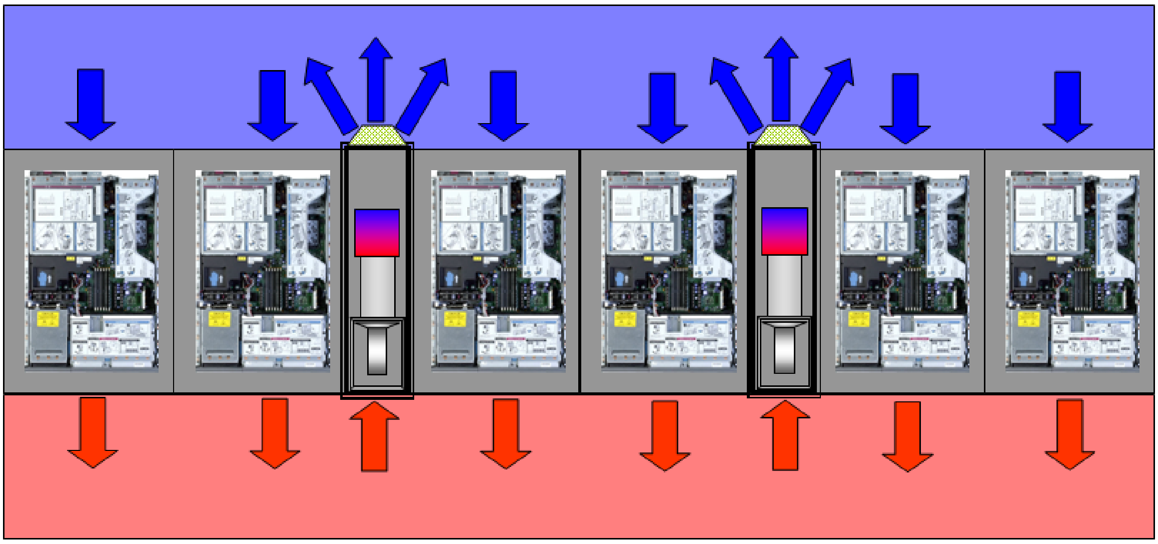

Figure 4: Function of the LCP Inline (viewed from above)

The LCP Passive

Whereas the LCP variants Rack and Inline are positioned in series with the racks, the Rittal TopTherm LCP Passive is fitted at the rear of the racks. This makes it well suited for retrofitting, since there is no need to move the enclosures, and it is quickly and easily exchanged for a standard rear door in the server enclosure.

The LCP Passive is a rear door with an integral heat exchanger. It is mounted on the rear of a rack and connected to the refrigerant supply lines in the base. The cold water passes through the heat exchanger and back to the recooler. The servers are responsible for air routing inside the rack, and must be capable of overcoming the pressure loss of the heat exchanger so that the hot air flows through the LCP Passive, out of the rack, and is cooled there (Figure 5). Before using an LCP Passive in a data centre, various infrastructure factors must be taken into account, as outlined in the following chapters.

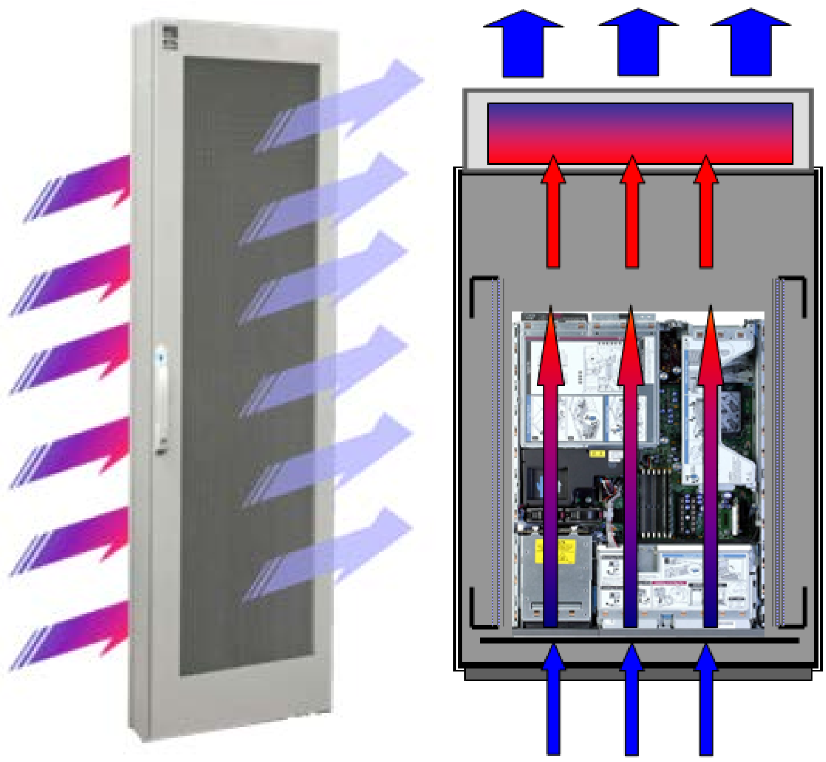

Figure 5: Function of the LCP Extend (right: Viewed from above)

There are no fans installed in an LCP Passive. Because there is no controller or temperature monitor, there is no need to connect it to the power supply or a network. An LCP Passive does not consume any electricity, and for this reason, is also particularly efficient, while achieving a useful cooling output of up to 20 kW. At the same time, the 482.6 mm (19”) equipment inside the enclosure is readily accessible, because the door has an opening angle of 120° despite the water connection.

The temperature, air humidity and airflow may optionally be monitored with the Rittal CMC III system. This system allows users to monitor various ambient values via sensors, and in the event of critical measurements, to alert a technician with a text message. Measurements can be retrieved and parameters can be set using a PC and browser.

Data centre infrastructure

Many data centres use ambient air to cool the servers in the racks. CRAC systems are used to cool the ambient air to a suitable temperature. CRAC systems are positioned in the data centres away from the rows of racks. They draw in ambient air – which rises due to its lower density compared with cold air – below the ceiling, and cool it down using a refrigerant. As in an LCP, a CRAC system is connected to a recooler via pipes. This lowers the temperature of the cooling medium and returns it to the climate control unit.
The cooled ambient air is transported into the raised floor by the CRAC system using a fan. From there, it is distributed within the room, and arrives in front of the servers via slotted plates. These draw in the air via the perforated rack door, and use it to cool their components. At the rear of the rack, the heated air is emitted to the environment once again and in this way, is returned to the CRAC system.

Typical layout of a modern data centre with a CRAC system

To support use of a CRAC system, the rows of racks must be suitably positioned within the data centre. Typically they are arranged in several rows (depending on the number of racks), as shown in Figure 6. The racks are positioned in such a way that heated air is always emitted into the same aisles (i.e. the space between the rows of enclosures) by the servers, and the slotted plates are always installed in the next row, so that there is alternation between the hot and cold aisles. The same layout is also implemented when using LCP Passive devices.

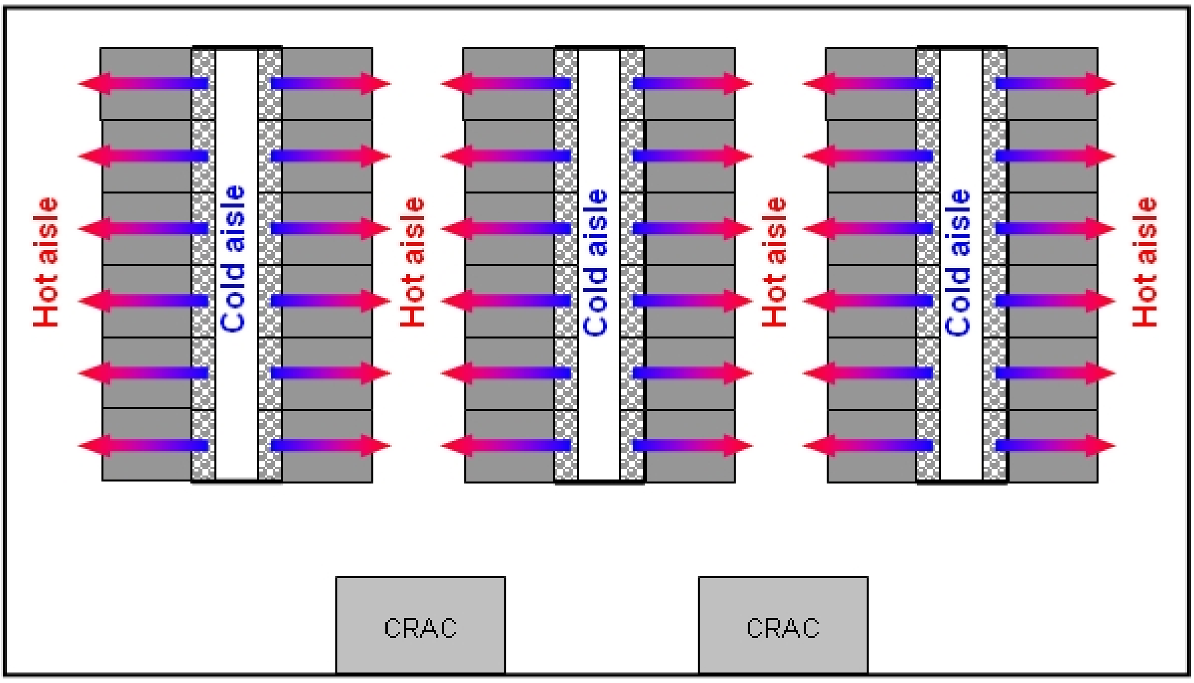

Figure 6: Typical layout of a modern data centre (viewed from above)

The efficiency of such a cooling system can be improved with aisle containment, whereby mechanical partitions are used to physically separate an aisle, although it remains accessible via a door. This installation prevents hot and cold air from mixing.

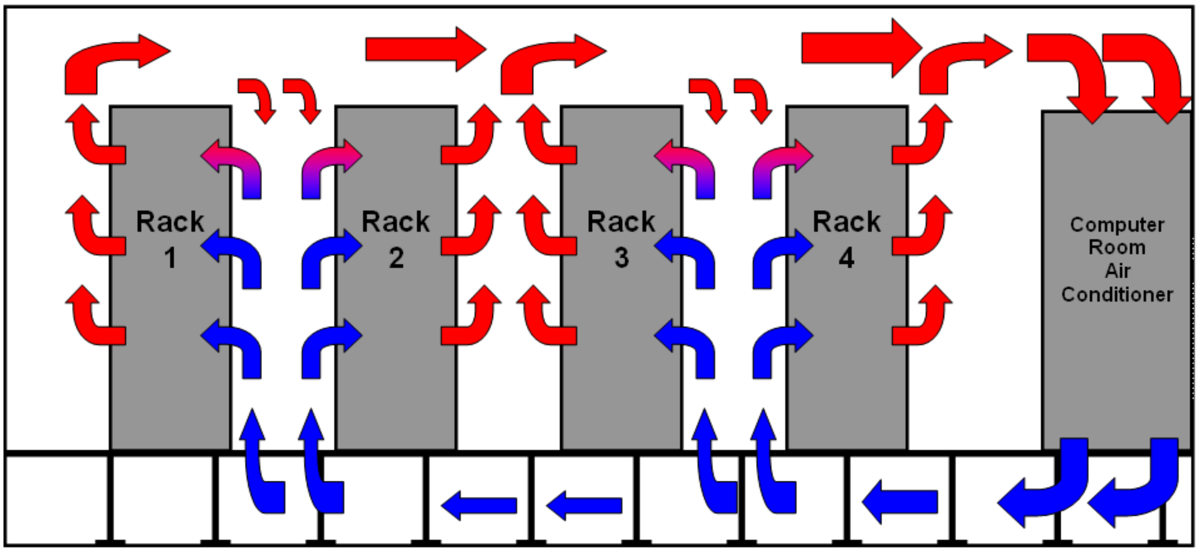

Figure 7: Air flows without aisle partitioning (side view)

Figure 7 shows the side view of a data centre with a CRAC system. The hot air that flows towards the climate control unit from rack 1 mixes with the cold air between racks 1 and 2, just as the hot air from racks 2 and 3 mixes with the cold air between racks 3 and 4. Consequently, the air that actually reaches the top servers in the racks is of a higher temperature. However, in order to supply the servers with sufficient cold air, the output of the CRAC system must be increased, leading to higher electricity consumption.

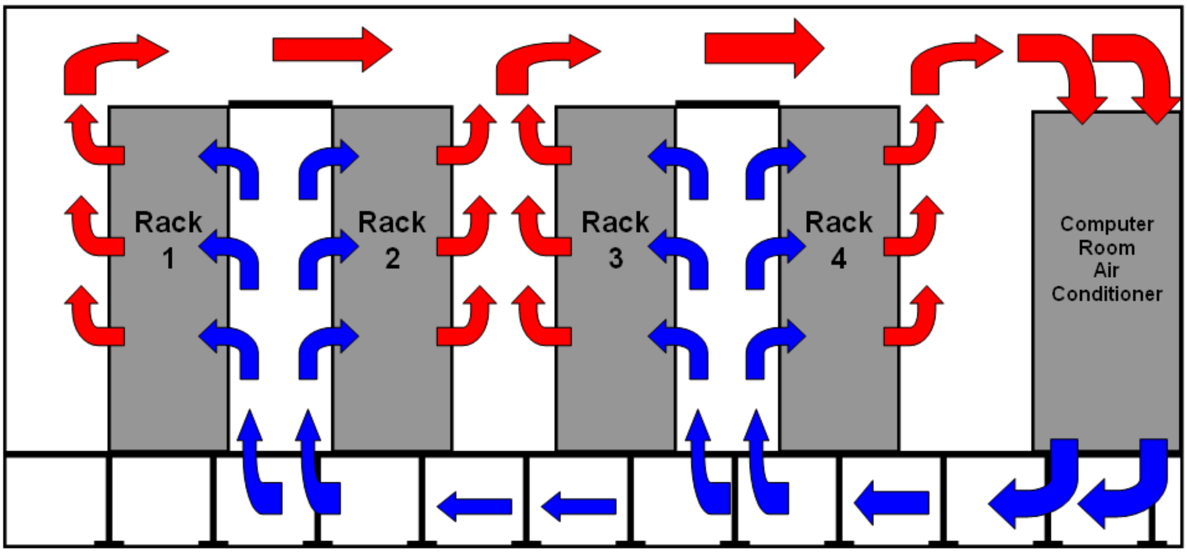

Figure 8: Air flows with aisle partitioning (side view)

Figure 8 shows the side view of a data centre with a CRAC system and cold aisle containment installed. Physical separation of the air flows means that the cold and hot air are no longer able to mix, and the entire system is able to operate at a higher temperature level. In this way, the CRAC system operates at optimum efficiency.

Infrastructure of a data system with the LCP Passive as cooling system

Certain requirements regarding the data centre infrastructure must be met when using the LCP Passive as a cooling solution in a data centre. These requirements arise mainly because there are no integral fans in the LCP Passive. Constant air circulation is initiated by the servers themselves rather than by a fan in the LCP. They ensure that the hot air is routed through the LCP Passive, and the cold air enters the racks. To this end, they must be capable of overcoming the pressure loss caused by the LCP Passive. This is only possible if there are no opposing air flows prevailing on the outlet side of the LCP Passive. In order to ensure this, the rows of racks must not be positioned in alternating directions, but must instead all route the air in the same direction.

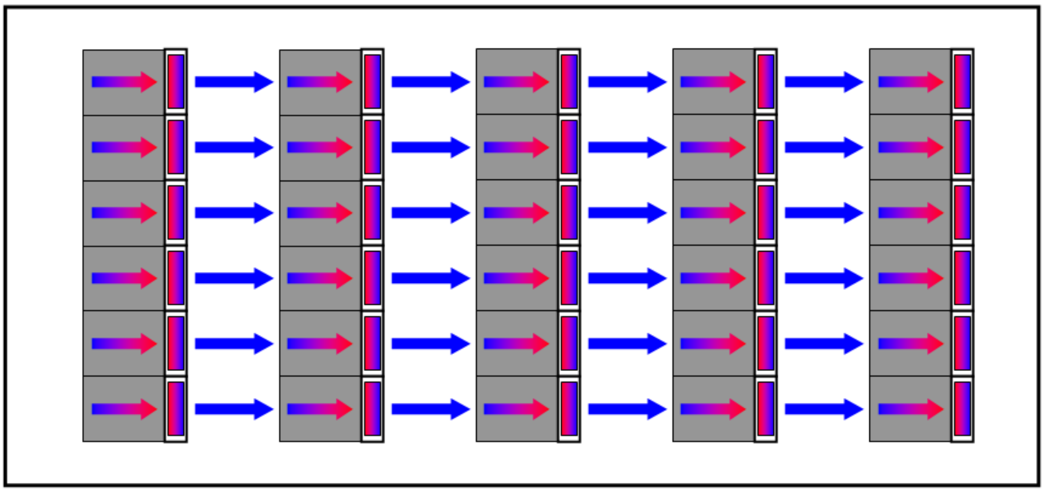

Figure 9: New infrastructure with the LCP Passive (viewed from above)

Figure 9 shows the required arrangement of rows of racks in a data centre when using LCP Passive units. It is particularly important to ensure that the air flows in a straight line and in one direction only. In this way, the air flow is continued by each server, allowing the pressure loss via the LCP Passive to be overcome more effectively.

The air flows through the racks in one direction in the room's lower zone. After the last row of enclosures, it flows into the upper zone, and back in front of the first row of racks below the ceiling. In this way, a complete air circuit is created.

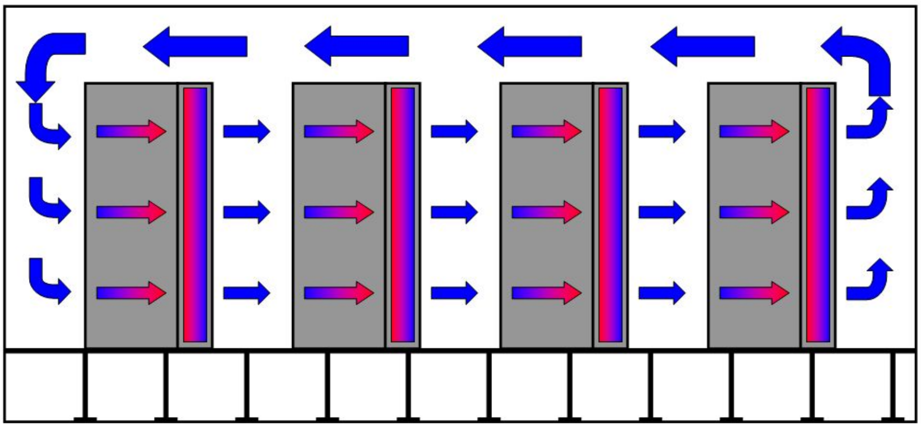

Figure 10: New infrastructure with the LCP Passive (viewed from the side)

If an LCP Passive is mounted or retro-fitted on an individual enclosure, here too it is important to ensure that there are no opposing air flows in front of the rack (Figure 11), for example caused by other racks; otherwise, the fans would be unable to overcome the pressure loss via the LCP Passive, and hot air would accumulate in the rack, leading to hot spots.
For this reason, before carrying out retro-fits and installations on individual enclosures, it is important to consider the air flows around the enclosure. Depending on the distance from a rack positioned opposite with an opposing air flow, it is necessary to check beforehand whether use of the LCP Passive is possible. By selecting a layout as shown in Figure 9, problem will not occur.

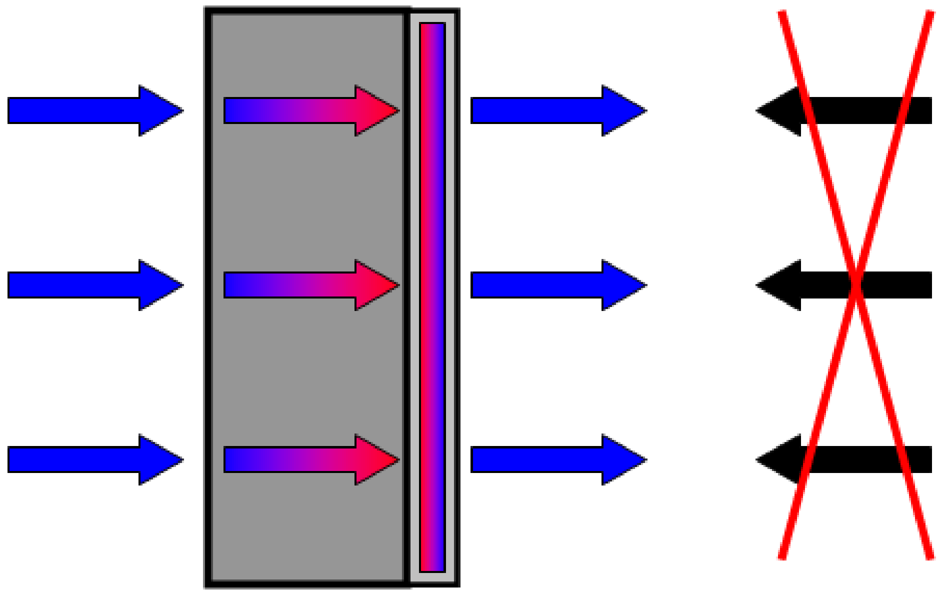

Figure 11: Avoiding opposing air flows (viewed from the side)

Layout of an individual rack with the LCP Passive

In the rack itself, special precautions must also be taken if an LCP Passive is to be used as the cooling solution. Firstly, it is important to ensure good sealing of the rack and the LCP Passive. Every pressure loss and associated air escaping from the enclosure will reduce the efficiency of this cooling solution. The hot air should be routed completely through the heat exchanger in the LCP Passive, if possible, in order to cool it down to make it available to the servers in the next rack. Secondly, with the LCP Passive, in contrast to the LCP rack, the partitioning in the rack must be positioned closer to the outlet side of the servers. Figure 12 shows a rack with servers and LCP rack. The LCP expels cold air into the enclosure on the server intake side. In order to ensure that the cold air does not flow past the servers, special sealing foam or air baffle plates (Figure 12, black rectangles) are used to separate the cold air zone from the hot air inside the rack. This ensures that air flows inside the rack do not mix together, and cooling is more efficient.

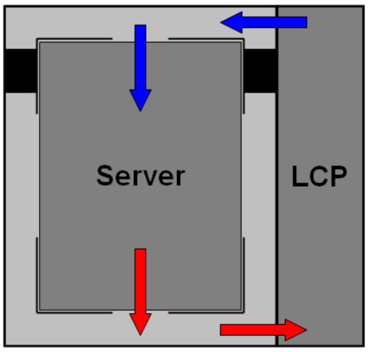

Figure 12: Partitioning with LCP rack (viewed from above)

In conjunction with the LCP Passive, however, the sealing foam/air baffle plate partitioning must be positioned differently. As shown in Figure 13, the hot air would accumulate next to the servers, as it is not drawn in by any fans, causing additional heating of the servers from the side. Conversely, by positioning partitioning on the hot air side – as shown in Figure 14 – the volume is reduced, so that hot air is able to flow through the LCP Passive via a short route.

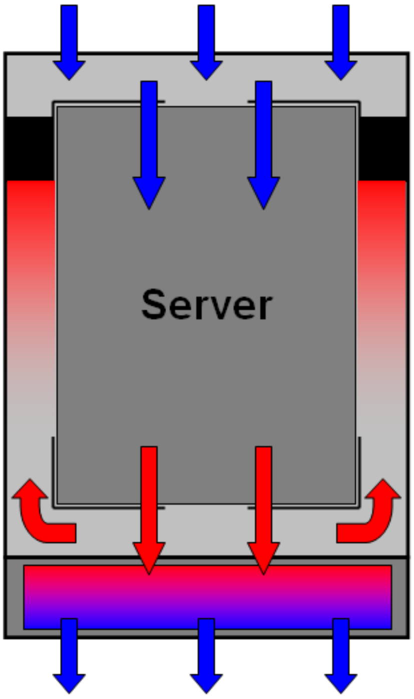

Figure 13: LCP Passive with old partitioning in the rack (viewed from above)

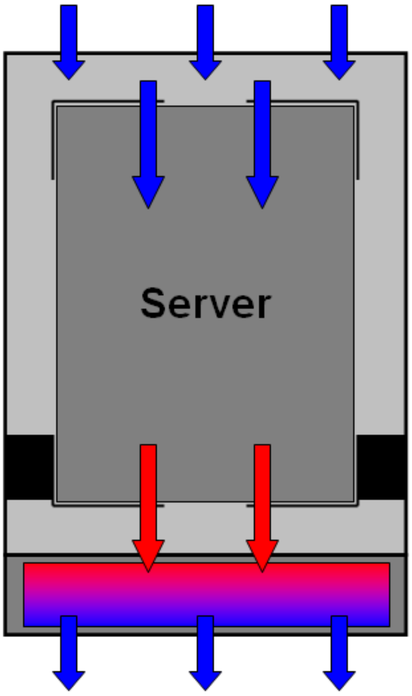

Figure 14: LCP Passive with new partitioning in the rack (viewed from above)

Summary

As server manufacturers pack more and more performance into an ever smaller area, the data centre infrastructure also faces ever greater demands in terms of efficiency and power saving. Finding a good balance between high output and minimal energy consumption is a challenge, especially for manufacturers of cooling solutions, since as the server output rises, so too do the heat losses that must be expelled from a server rack in the form of heat. With this in mind, Rittal has added the LCP Passive to its TopTherm LCP series.

The LCP Passive does not have its own fans and therefore also does not consume any electrical power, giving it a very high level of efficiency. The air is only routed through the server fans via the heat exchanger in the LCP Passive, and particular attention should therefore be paid to the infrastructure of the data centre and the ambient conditions surrounding an enclosure with LCP Passive.

Whereas modern data centres with a CRAC system arrange the rows of racks with alternating hot and cold aisles, this arrangement is not appropriate for data centres using LCP Passive units. Outside of the racks, there is only one flow of cold air, which flows from the outlet side of one row to the intake side of the next row. This creates an air circuit in which all racks expel the air in the same direction. Additionally, within a rack it is important to ensure that the partitioning between the servers and the enclosure wall is installed on the side of the LCP Passive, so that no unnecessary hot spots are created within the rack.

The LCP Passive offers a good alternative to conventional cooing solutions. Particularly for new data centres, but also as a retrofitted solution, the LCP Passive is the ideal choice provided the infrastructure and ambient conditions permit. The big advantage of the LCP Passive is that there are no fans integrated, and for this reason it does not consume any electricity and is therefore very efficient.

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List of abbreviations

CMC	-	Computer Multi Control
U	-	Height unit
IT	-	Information technology
LCP	-	Liquid cooling package
PC	-	Personal computer
TWh	-	Terrawatt hour
UKS	-	CRAC system

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