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1 Executive Summary

Climate control of IT systems is crucial to their availability and safety, and thus for the business operation – it is relevant to the whole company!

Continuously increasing integration and packing density of processors and computer/server systems cause waste heat quantities which were inconceivable for such restricted space a few years ago. A server rack with 30 most up-to-date Intel processors delivers such waste heat that would be sufficient for operating a sauna!

Depending on the power (dissipation) of the computer components used, different cooling solutions are available on the market – up to CPU liquid cooling. Apart from the available range of climate control components, their compatibility with the enclosure/rack systems used is decisive. Apart from the possibility of an easy retrofit of most different climate control solutions, best possible systems stand out due to the fact that all components complement each other in an ideal manner. In this way investments already made are protected.

An outstanding solution is completed by comprehensive monitoring solutions – besides the planning and implementing competence of the rack/climate control system supplier. It is indispensable to gain clear information about the climatic conditions in the data centre or in individual racks.

The delivery of racks, climate control components and monitoring solutions that can be integrated into management systems from one hand offers the customer a maximum degree of reliability. Apart from that, a good system supplier also stands out for the ability to offer project support from the very start. In this way safe solutions are created for a secure business operation.

Rittal RimatriX5 –
The future of data centre security

Whether in small businesses or major enterprises – the demands placed on IT performance are growing incessantly. Highly complex applications, ever faster processors, and round-the-clock information and communication call for more than just an intact physical infrastructure. With RimatriX5 – Driving IT Performance – Rittal is now offering an integrated overall concept for modern data centres with comprehensive service and five perfectly matched IT modules: Rack, Power, Cooling, Security and Monitoring/Remote Management. Users are presented an all-round solution for a secure, available and cost-saving IT infrastructure.

Further information at: www.rimatrix5.de
2 Climate – definitions and significance to IT

Climate control stands for a well-directed influence on the parameters

- Air temperature
- Atmospheric humidity
- Air speed and direction of flow
- Air pressure
- Contents of harmful substances and composition of harmful substances

The climate is crucial to the reliability and thus the availability of electronic systems. In IT environments especially the temperature is the worst enemy of the sensitive microelectronics. In case of semiconductors, there is the rule of thumb that an increase in the ambient temperature by 10 °C (in relation to the permissible maximum operating temperature) reduces their service life by half. Climate control is inevitable, owing to the sometimes unfavourable installation conditions and the increasing power dissipation of computer systems.

All electronic components dissipate heat during their operation, which is called power dissipation. This energy must be carried away from the components and led outwards. The heat transfer occurs essentially by means of thermal conduction – i.e. by transmission from particle to particle – or by convection – absorption of energy by a liquid or gaseous transport medium. Since electronic components dissipate only small quantities of heat in the form of thermal conduction, heat removal in the form of convection must take place. Since air is a bad conductor of heat, the removal of the power dissipation is limited owing to the small radiating surface – even if further heat sinks with cooling fins additionally increase the surface. Liquids are clearly better media for the heat transport. Water, for example, conducts the heat many times better than air. For this reason the significance of liquid cooling increases together with the growing processor capacity and packing density.

2.1 Permanently increasing power dissipation

Despite all revolutionary changes in information technology (IT) over decades, only little changes have taken place in the field of data centre cooling. Cooling has always been necessary. However, only the permanently increasing packing density (transistors per chip and processors per board) as well as the uninterrupted increase in processor clock-pulse rates have led to rapidly increasing thermal problems which have to be taken into consideration as early as during the planning of systems, racks and data centres. The power dissipation – or to speak simply: the waste heat – increases in proportion to the computing power.

Moore’s prediction according to which the number of transistors per chip doubles every 18 months, is still valid. The following graphic chart portrays this development, and no curve flattening can be expected.
Apart from the increase in computing power which is conditional upon technological progress, the space required is an important aspect with regard to the removal of power dissipation. One the one hand, regular costs accrue for every room – and especially for rooms in data centres which are secured several times. The rent, for example, is one cost item here. This is only one reason why miniaturisation of computer components is advantageous to the space required. Best possible racks with a high net volume and flexible baying possibilities at all levels support the progress with a good space/performance ratio. However, at the same time an enormous power dissipation is created in a very confined space, and this power dissipation must be managed in the sense of system availability.

2.2 Packing density in the rack / on board

With more than 130 W/cm\(^2\) per CPU at present (status as per 2005) – this corresponds to two standard incandescent bulbs per sq. cm. – the task of ‘data centre climate control’ takes shape. Despite a wide choice of heat sinks, the removal of power dissipation by means of air cooling becomes more and more difficult.

According to measurements and practical experience, power dissipations of up to 3 kW in one rack/housing are still controllable with conventional double bottom cooling applied in many data centres. Commercial data centres are, for the most part, still sufficiently cooled. In the technical/scientific area, so-called blade servers cause power dissipations of already 10 kW per rack.
In the foreseeable future this value will double again, owing to increasing performance with simultaneously decreasing component size – or to speak simply: The power density increases.

The following figure shows a high-performance cluster of the Utrecht University with 70 Intel Xeon processors and a waste heat of about 11 kW. At the same time it becomes apparent that this enormous performance is created in a very compact space and must be carried away from there, as well. Conventional fan solutions have to be ruled out – as one can see from the installation.

CPU liquid cooling of a high-performance cluster mounted in the rack. 11 kW are carried away from there.
3 Climatic conditions for IT systems

All-purpose office buildings usually only meet low technical requirements, so that they can be used for most different purposes. IT systems or, properly speaking, data centres are accommodated in rebuilt office infrastructures with limited dimensions then, in the absence of alternative solutions especially designed for such purposes. Due to this fact the subject of climate control becomes even more complex, because, apart from the space required and the frequently missing air conditioning technique, further problems such as noise emission and expensive fire protection must often be observed.

From this point of view it is easier if IT systems are installed in industrial environments. Such environments have sufficient space, and noise is no problem. However, in such areas problems regarding air pollution, vibrations and possibly high temperatures can arise. That is why one also has to pay attention to a high protection category of the enclosures, apart from the climatic outline conditions, since open and vented racks must of course be ruled out – which additionally complicates the climate control.

Closed enclosures in an industrial environment – a challenge to climate control

Recommendations for the operation, subdivided into classes

Most of the electronic systems are subdivided into particular classes which predetermine safe climatic outline conditions for operation and rest. If, for example, one contemplates the classes 1 and 2 in the operating state, the optimum temperature poses a real challenge to every rack tightly equipped with active components.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15 - 32</td>
<td>20 - 25</td>
<td>20 - 80</td>
<td>40 - 50</td>
<td>3000</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>10 - 35</td>
<td>20 - 25</td>
<td>20 - 80</td>
<td>40 - 50</td>
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<tr>
<td>3</td>
<td>5 - 35</td>
<td>-</td>
<td>8 - 80</td>
<td>-</td>
<td>3000</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>5 - 45</td>
<td>-</td>
<td>8 - 80</td>
<td>-</td>
<td>3000</td>
<td>-</td>
</tr>
<tr>
<td>NEBS</td>
<td>5 - 40</td>
<td>18 - 27</td>
<td>5 - 80</td>
<td>25 - 55</td>
<td>4000</td>
<td>-</td>
</tr>
</tbody>
</table>

Definitions:
- Klasse 1: Sorgfältige Kontrolle der Klimaparameter: für Doppelboden Equipment
- Klasse 2: Normal Kontrolle der Klimaparameter: für Server und Speicherprodukte
- Klasse 3: Leichte Kontrolle der Klimaparameter: für Workstations, PCs und Drucker
- Klasse 4: Keine Kontrolle der Klimaparameter: für mobilem Einsatz
- NEBS: Sorgfältige Kontrolle der Klimaparameter: für Telekommunikationsequipment

Betriebszustand: Das Produkt ist gerade im Betrieb
Ruhezustand: Das Produkt ist installiert, aber nicht im Betrieb: wegen Reparatur
4 Air cooling and options

The easiest possibility of heat removal takes place through the housing surfaces of an enclosure, provided that the ambient temperature is lower than the internal temperature. However, only smallest amounts of heat can be dissipated in this way.

Example: \( W = k \cdot A \cdot \Delta t \)

- \( \Delta t = 10 \text{K} \) (temperature difference on the inside/outside)
- Enclosure 800 x 2000 x 900mm \( \Rightarrow A = 7.13 \text{ m}^2 \).
- A dissipatable amount of heat of approximately 5.5 W/sq.m.K results from this.
- Result: with a closed enclosure, a power dissipation of approximately 315 W can be carried away, and a power dissipation of approximately 600 W with an open enclosure.
- The result can be improved to 1,500 W, if rack-mounted fans with an air output of 3.2 m\(^3\)/h per W/K accelerate the air circulation under the same preconditions in the closed enclosure.

The next possibility is a passive ventilation of the enclosures. The air exchange takes place through specific open spaces in the base/plinth, roof plates and/or doors and side panels, according to the rule: cool air coming in at the bottom/front and hot air coming out at the top/rear.

This structure is mostly insufficient in case of high packing density. For this reason forced air cooling must be applied. In the range of accessories offered by housing system suppliers, such as Rittal, you will find special solutions meeting the requirements, provided that the temperature drop between enclosure inside and ambient temperature is sufficient. By use of appropriate modules, the enclosure roofs can be lifted or equipped with powerful fans drawing in cool air at the bottom and releasing hot air into the environment at the top. However, cool ambient air required for this can for the most part only be provided in air-conditioned rooms, such as data centres. This simple solution is not suitable for
every application, due to the noise level of the fans – e.g. in office areas – even if air conditioning equipment ensures a cool ambience there.

Both requirements, i.e. high air output/cooling capacity and lowest possible noise level, must be met here at the same time.

If this quite simple solution must be ruled out, the use of special ventilation and cooling components is required for successful climate control.

4.1 Air output

The following table provides information about the maximum air flows reached by different fan modules suitable for racks.

<table>
<thead>
<tr>
<th>Fan Module</th>
<th>Luft Stufe 1</th>
<th>Luft Stufe 2</th>
<th>red. Luft</th>
<th>Rack</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL360G3 1U</td>
<td>68m³/h</td>
<td>109m³/h</td>
<td>N/A</td>
<td>4560m³/h</td>
</tr>
<tr>
<td>DL380G2 2U</td>
<td>51m³/h</td>
<td>73m³/h</td>
<td>N/A</td>
<td>1534m³/h</td>
</tr>
<tr>
<td>DL380G3 2U</td>
<td>68m³/h</td>
<td>103m³/h</td>
<td>80m³/h</td>
<td>2140m³/h</td>
</tr>
<tr>
<td>DL580 6U</td>
<td>204m³/h</td>
<td>328m³/h</td>
<td>N/A</td>
<td>2293m³/h</td>
</tr>
</tbody>
</table>

Source: Rittal

4.2 Temperature distribution – integral approach

In the sense of an integral approach, not only the air supply into a rack, but also the distribution on a small and large scale is important for an efficient cooling. This means that specialists always contemplate the whole picture for a safe system operation – from the air distribution in the server and the distribution in the rack with components fitted, up to the temperature distribution in the data centre. With the help of modern visualisation procedures, the heat distribution becomes visible. This comprehensive approach is important, since in this way hot spots in the rack as well as in the room can be avoided. Problems with regard to the removal of heat can arise even in air-conditioned rooms, since the planned flows of room air conditioning mostly follow other specifications than those for cooling sensitive technical equipment.

Rittal, specialising in racks and climate control, offers a software solution especially developed for the planning stage of a rack. It supports the determination and documentation of climate control components suitable regarding their capacity, on the basis of specified power dissipations for every individual enclosure. A database stored in the background contains information about housings and climate control components, and another one – which can be edited – provides the power dissipations of common power electronics. Apart from the necessary air output and cooling capacity, the programme also provides information about the air routing.
4.3 Air flow and orientation

The well-directed orientation of the air flow plays a decisive role, even for already air-conditioned room air and therefore a positive $\Delta t$ between enclosure inside and air-conditioned room air as well as relatively low thermal losses in the enclosure. Flexible, well thought-out rack systems permit a variable air routing. E.g. front and back doors with large-surface perforations permit a horizontal air routing from the front to the back, through the equipment. Mostly this type of flow is additionally supported by fans integrated into the computer systems.

Two possibilities of the air routing in racks, horizontal or vertical

In case of raised floor cooling, closed enclosure doors can be used as an alternative, so that a vertical air flow from the bottom in an upward direction is forced. At the same time it must be clear that both types cannot safely prevent the creation of hot spots in highly loaded systems, without taking further measures in the form of air baffles or auxiliary fans.

4.4 Problems regarding the air routing with raised floors

The raised floors introduced as early as in the classical mainframe data centres, does not meet today's partly extremely high requirements with regard to its air routing anymore. It is no wonder, because mainframes did not have high power dissipations in relation to their capacity and constructional volume. Moreover, the really large systems were cooled with liquid even in the past. Now this trend also catches up with all compact, very powerful computer systems – especially those with blade servers.
4.4.1 In the room

In some simple systems, even with raised floor, the cooling air heats up more and more in the course of the air routing through the systems from one rack row to the next, so that the ‘last’ systems in the room might be insufficiently supplied with cold air (see the following graphic chart). Intelligent air routings are required here to derive maximum benefit from raised floor climate control.

Further problems arise by an unsuitable air routing.

- A low ceiling decreases the air volume
- Internal re-circulations and backflows at the row end are created
- Gland plates with too low through-flow and too low pressure in the raised floor
- A bad co-ordination of the air distribution from the heat exchangers (CRAC) can, if the worst comes to the worst, suck off cooled air from the enclosures again. Combined with backflows at the end of the row, hot spots are created (see the following graphic chart)

Abbreviations:
HVAC – Heating Ventilation Air Conditioning (simplified: heat exchanger)
CRAC – Computer Room Air Conditioner
The best performance is achieved with a raised floor in connection with a double ceiling. The following structure promises best results:

Diagrammatic representation of the air routing with raised floor/double ceiling

The ideal design of raised floor and double ceiling

Diagrammatic representation of the air routing with raised floor/double ceiling
4.4.2 In the rack

A well-directed air routing in the rack/enclosure is also decisive. Not only the air volume determines the cooling capacity of the installation, but also the systematic air flow against subassemblies with high waste heat. An exact analysis by specialists identifies the hot spots. For an efficient cooling, the delivery range of housing system suppliers contains air routing systems as well as fan walls which ensure a better air circulation on particular levels, than this would be possible by the fans installed in the computer systems. Fans in the rack support the well-directed air distribution, also in connection with raised floors.

The structure of a rack can be one cause for difficult air conductions. Asking for support by rack and climate control specialists is recommended here. In case of doubt heat picture recording gives information about the position of problematic spots.

Possible heat distribution in a rack, displayed by simulation of Computational Fluid Dynamics (CFD)

The air flow through the equipment is desired. However, air short circuits can easily take place, e.g. if free planes are not closed by blanking plates (see the following graphic chart).

Possible problems regarding the air routing in a rack with doors perforated at 65% at the front and rear
**Recommendation**

1. Place the enclosures with front or reverse sides to each other (cold isle/hot isle)

2. Close any empty 19” slots with dummy plates so that no recirculation will occur

3. For the best possible air flow against trouble spots, integrate air routing systems into the rack

4. Design the maximum cooling capacity according to real, but not to electric power dissipation and don't exceed

5. Do not relate the cooling capacity to the space, but to the racks

6. Avoid hot spots, evenly distribute thermal loads in the room

7. Do not exclusively put the racks together according to function, but also according to power dissipation

### 4.5 Air/air heat exchangers

The cooling of computer systems in enclosures must meet special requirements, if such systems are installed in a dirty ambience, e.g. in industrial areas. Such installations are more and more frequently required due to the progressive use of microprocessor-controlled solutions in the production converging with ‘classical’ IT networks. In such cases the air inside the enclosure must be separated from the surrounding air. Air/air heat exchangers are the better solution in comparison with filter fans that only remove coarse pollution from the surrounding air.

#### 4.5.1 Preconditions for use

In any case, air/air heat exchangers can only be used if there is a temperature drop between inside and outside to such an extent that the outside temperature is clearly below the internal temperature.

#### 4.5.2 Ranges of application

They are used in closed rooms with polluted air as well as in outdoor installations so that not only polluted air, but also insects and any other harmful influence are kept away from the installed equipment of an enclosure.

### 4.6 Air/water heat exchangers

Air/water heat exchangers expand the spectrum of air/air heat exchangers by the possibility of cooling an enclosure system even without any temperature difference between interior and surrounding air. Inside the enclosure, a heat exchanger is used that is supplied with ‘cold’ cooling water from the outside. The air in the enclosure is circulated by means of appropriate fans. Interior and surrounding air remain separated from each other. The water is cooled down in external cooling water systems with appropriate recooling systems. They are delivered together with the enclosure systems or are already available for other cooling and air conditioning tasks at the place of application.
4.6.1 Possibilities

Modern air/water heat exchangers make cooling capacities of up to 30 kW possible. Like in most of the other air-routed cooling applications, fans in the enclosure generate a highest possible air volume flow. Up to 4,500 m³/h are possible. A water volume flow with a flow rate of up to 50l/min is required in the cooling cycle for it. Air/water heat exchangers are available in different constructional designs. System suppliers offer a variety of solutions, from cooling side panels/doors up to plug-in coolers with corresponding fans. An ingenious internal air routing can prevent the creation of hot spots. Please refer to point 4.2 in this connection.

4.6.2 Ranges of application

Areas where high power dissipations must be carried away, are to be especially considered as ranges of application. Permanent power dissipations exceeding 4 kW/rack can neither be safely managed with ‘normal’ fans in the rack/enclosure nor by means of raised floor cooling. In such cases the cooling capacity in the rack can considerably be enhanced by liquid cooling. Another advantage is the noticeably lower noise level of such installation, since the fans are operated on the enclosure inside and recooling systems are mostly installed remotely (outdoors). An advantage of the air/air heat exchangers applies here, as well: The closed enclosure inside is protected against any possible polluted surrounding air.
4.7 Characteristic features of the air/water heat exchangers – Rittal Liquid Cooling Package

- Complete accessibility of the 19" level
- Absolute even distribution of the cold air in front of the 19" level
- Standard cooling capacity of 4 kW/module, can be scaled
- Retrofitting is possible in the running operation
- Integration into an integral (remote) monitoring system
- Climate control is temperature-neutral for the place of installation
- Two enclosures can be cooled with one air/water heat exchanger, as well, by installation between two enclosures

4.8 Cooling units

If no positive temperature difference between enclosure inside and ambient air exists, and the heat can be carried away into the direct environment, cooling units come into consideration. They are available as rack-mounted cooling units (6 U, 19") as well as climate controlled enclosures, and climate control doors and side panels. Roof-mounted cooling units – also installed subsequently – are often used, as well.
Air routing with a door-mounted cooling unit

The advantage is based on the production of cold directly on the spot. Thus external cooling systems and cycles become unnecessary. Another advantage is the possibility of an easy retrofit. With the increasing performance of the computers in the enclosure, a suitable climate control solution can be retrofitted without expensive installation work at any time, subject to appropriate environmental conditions.

However, this installation option on the spot imposes a certain restriction, because the waste heat must be taken up from the operational premises and carried away, if required. Another side effect is the unavoidably slightly increasing noise level in the direct surrounding field of the enclosure.

4.9 Comparison between different cooling solutions regarding their power spectrum

<table>
<thead>
<tr>
<th>Produkte</th>
<th>Leistungsspektrum</th>
<th>Extras</th>
<th>Anmerkungen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Einschubkühler 6HE, 19°</td>
<td>1000W</td>
<td>keine</td>
<td>eventuell Ausbrüche in der Tür benötigt zur Luftversorgung</td>
</tr>
<tr>
<td>Integrierte Kühltechnik, Klimaschaltschränke, -türen und -seitenwände</td>
<td>1100 - 2500W</td>
<td>Sockelblenden</td>
<td>Sockelelemente werden benötigt</td>
</tr>
<tr>
<td>Kühleräte</td>
<td>225 - 4000W</td>
<td>Filter, Regelungs- und Überwachungszubehör</td>
<td>verschiedene Ausführungen erhältlich: Dachaufbau und Wandanbau</td>
</tr>
<tr>
<td>Luft/Wasser Wärmetauscher</td>
<td>500 – 25.000W</td>
<td>keine</td>
<td>Kühlwassersystem benötigt</td>
</tr>
<tr>
<td>Luft/Luft Wärmetauscher</td>
<td>17,5 - 80W/K</td>
<td>Temperatur- und Drehzahlregler</td>
<td>keine</td>
</tr>
</tbody>
</table>
5 Cooling solutions for highest capacities

The increasing packing density mentioned at the beginning, and the power dissipation associated with it increasingly require cooling applications where air as transmission medium has to be ruled out. The heat created must be carried away from the place of origin. This means at the processors, because they cause the largest part of the power dissipation. However, other components (memory, hard disks, power packs) and their power dissipations must not be forgotten either. They are ‘traditionally’ cooled in the same enclosure.

5.1 CPU liquid cooling

The increasing waste heat in computer systems with high packing density can only be managed with liquid cooling applications in future, because the waste heat mainly comes from the small surface of the CPUs.

Why liquid cooling?

The answer can be given in a few notes:

- The cooling capacity can be placed very exactly
- Lower noise emission
- Saving of energy by the operation in Free Free-Cooling Mode or with radiators

- High inlet temperature (compared to air/water heat exchangers) for increased energy efficiency
- “Temperature-neutral” enlargement of data centres
Functional preconditions are an existing cooling liquid system or a new one to be installed, components relevant to the application as well as the integration into the respective enclosure housings. Insertion into the rack – especially in case of retrofit – can lead to loss of space. Some solutions require a lot of space for the installation of water risers and distributors. Modular system solutions, e.g. from Rittal, integrate risers and distributors into the enclosure frame sections. Therefore they do not restrict the net space.

A safe connection system is indispensable for the connection of the liquid cooling, to avoid any contact between water and electronics. Nowadays warranted non-dripping connections guarantee maximum safety. They can be disconnected even in a running operation, if system upgrades or maintenance work are to be carried out. The cooling water supply for larger installations is mostly carried out by means of recomilers located outside the data centre. In this way already existing room air conditioning units are not additionally loaded by the waste heat of the liquid cooling. Another advantage is the reduction of the noise level in the data centre or server room, because only a few fans are required in the server rack. Apart from that, a mini-recooler, e.g. from Rittal, is available for individual liquid-cooled racks. This mini-recooler is integrated into the 19" level.

5.1.1 Possibilities
A lot of solutions and processor heat sinks that can be retrofitted, are available on the market.
5.1.2 Structure of the heat sinks

To absorb the waste heat of the processors fast and with low amounts of water, heat sinks consisting of a stack of microstructured copper plates on the inside were developed. The channel depth is 200 µm and the channel width is 500 µm. The large surface/volume ratio guarantees maximum heat transport. In this way up to 250 W/cm² are carried away from the hot spots.

Rittal regularly checks the cooling components for performance, security against fracture and any possible deformation in own laboratories to offer the customers maximum safety during use. These cooling systems are for example tested with a water pressure of up to 80 bar (!). If the recommended cooling liquids are used, the microchannels are neither blocked by algae nor by corrosion, even in continuous operation, since both would have fatal repercussions.
**Characteristic features of CPU liquid heat sinks**

- Excellent efficiency
- Highest quality standards (certified by the German Technical Inspection Association)
- 100 ml/min per CPU are already sufficient
- Small and lightweight (air-copper heat sinks weigh up to 900g)
- Small, flexible fittings
- Small hose diameter (outside diameter is 4 mm)
- Compact pumps are possible
- Easy and safe handling
- Industrial mass production

### 5.1.3 Overview of liquid cooling

- **Decision factors:**
  - maximum power dissipation to be expected, installation conditions, cost of acquisition, operating expense, cost of enlargement, safety in future, downtime cost, physical safety etc.
  - **The one and only** IT cooling does not exist. After analysing the exact requirements and planning for the future, the cooling strategy selected is to be realised with high-quality components.
  - Power dissipations of 25+ kW per rack can be carried away easily, safely and efficiently with liquid.
  - Liquid cooling can be managed from a technical point of view.
  - High, potential energy savings due to considerably higher inlet temperatures (compare with air/water heat exchangers).
  - This technology meets the cooling capacity requirements of the next years
  - Adaptation to existing data centre structures is necessary (and possible), change-over from room to rack air conditioning.

### 5.1.4 Recoolers

Cooling water with the required inlet temperature is made available by suitable recooling systems. A combination with existing liquid cooling applications is possible, as well as the construction of special recooling systems for the IT system cooling. System suppliers with air conditioning know-how can give the companies comprehensive advice, and use available resources in the best possible manner. Recoolers are – depending on their output – available from rack-mounted versions on a 19" pitch pattern for use in the enclosure, up to external radiators for outdoor installation.
Recycling in brief

- Water flow per rack (with 32 dual boards) approximately 6.4 l/min at 1.5 bar
- Riser ½” per rack
- Typical CPU temperature is 10 – 15°C above the cooling water temperature
- Consequence: Cooling water temperatures around 35°C are sufficient
- Redundant pumps are available, with circadian exchange of pumps

5.1.5 Characteristic features

In an enclosure with powerful computer systems, power dissipations are not only generated by the processors – even if their portion is the highest one. Their heat is ideally carried away by means of liquid cooling, because efficiency and “high” inlet temperature guarantee an economical and equally safe system operation. Apart from the CPUs, the main storages, hard disks and power packs also generate considerable waste heat. Therefore additional, well-directed air cooling is required for the waste heat removal from every enclosure completely fitted with components. Such air cooling can either be obtained from an existing raised floor, or – depending on the performance – be realised by air/air heat exchangers, air/water heat exchangers or climate control units.

5.2 Comparison between cooling solutions with regard to their capacity
5.3 Evaluation / help for making decisions

The above table helps you in choosing the required climate control components – from simple fan solutions up to CPU liquid cooling. The actual power dissipations are the decisive factor. Since power dissipations can change quickly upon expansion of the hardware, a co-operation with a reputable and experienced partner for enclosure and climate control is recommended, because there is a diverse dependence between both factors. Best solutions are always designed in such a manner that investments are comprehensively protected. That is to say, subsequent expansion is possible – of the rack as well as the climate control. In this way all components of a data centre grow with the requirements – computer, racks and climate control. Besides, an experienced company specialising in climate control and racks offers support in tracking air conditioning problems and eliminating them. Such company for example uses simulation software solutions and heat picture cameras. If excessive power dissipations have to be carried away, own laboratories of the supplier should be able to analyse the systems in real-time mode.

**Tip:** Contact your supplier and enquire about the possibilities of rendering support in complex projects!
6 Control and monitoring of the climatic conditions

Equipment of extremely high value is installed in modern server racks. Such equipment installed in the racks is not only protected against unauthorised access, but is also provided with sensors for most different environmental conditions. Electronic monitoring systems, such as CMC (Computer Multi Control) made by Rittal, record the environmental conditions and release an alarm in good time if particular specified values are not complied with anymore – even in the use of liquid cooling.

![Diagram of sensor plan for a heat exchanger side panel]

The evaluation of a survey shows the factors that are of greatest importance to the customers:

The temperature comes first, because electronic systems are very susceptible to too high temperatures. The access control follows directly. It can also be realised electronically via network. Smoke, water and vibration sensors follow at a greater distance – depending on the place of installation – as well as the possibility of connecting the monitoring device with the interfaces of other devices that release alarms on their own – e.g. UPS devices.
With such a checking system, all actual values (temperature, air humidity, voltage), desired values and any status information are passed on by means of most up-to-date transmission technology or SNMP protocol ("Simple Network Management Protocol") to correspondingly equipped management systems, and are evaluated there. In case of any fault scenario, they raise an automatic alarm to the administration staff – either on the management console, or as SMS or e-mail.

The ratio of the expenses for monitoring is 1 : 50 compared with the value of the enclosure contents.

Tip: Do not rely on the mere promise made by the climate control specialists. During the operation of your servers, monitor the environmental conditions continuously and with appropriate solutions.
7 Information about the author

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is working in the international product management for climate control of enclosures at Rittal. His area of responsibility mainly focusses on new applications, such as IT cooling, which also include the infrared thermography and CFD heat flow simulation (Computational Fluid Dynamics), just to give some examples.