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Whitepaper Rittal Liquid Cooling Packages

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Executive Summary

The Liquid Cooling Package (LCP) from Rittal is an efficient cooling solution for the dissipation of high heat losses from IT racks. Both suite-based and rack-based variants are offered within the LCP product family. In this way, it is possible to cater for a broad range of applications, for example two rack suites in conjunction with aisle containment, or equally the cooling of single IT rack enclosures. There are basically two heat transfer media with which LCPs can be operated: Water and refrigerant. Where several LCPs are used for cooling, it is generally water which is circulated within a closed cooling system to remove the heat from the point of loss in the server rack via a corresponding chiller. LCPs which use cold water as the cooling medium include the abbreviation “CW” (“Chilled Water”) in their product designation. They enable users to dissipate even very high thermal loads of up to 55 kW per rack. This is frequently the case with High-Performance Computing (HPC) applications.

For applications with smaller heat losses, and wherever no cooling water supply is available, a refrigerant-based LCP version is used. This variant is indicated by a product designation with “DX” (standing for “Direct Expansion”). The DX variant of the LCP is especially suited for installations and single-enclosure applications with small to medium heat losses, as is typical in many smaller and medium-sized enterprises (SMEs). The system dissipates thermal loads of up to 12 kW, irrespective of whether this stems from a single rack or from several racks. The LCP can be monitored permanently via a display on the unit itself, or by way of an Ethernet network interface and management software. The display, for example, enables setpoints to be entered for all temperatures and fan speeds, and any arising alarm messages are presented as plain text. The controller is furthermore able to report error states to a technician automatically, so that the necessary action can be taken to restore regular operation as quickly as possible. Compared to typical water chillers, the condenser unit of the refrigerant-based LCPs is relatively small and occupies only a minimum of space; this saves costs and simplifies installation.

Rittal's LCP product family is especially energy-efficient, thanks to its optimised system design and control functions. Even where the feed-side temperatures are very high, as is the current trend, high useful cooling outputs are achieved. This means that the proportion of indirect free cooling over the course of a year can be increased: This serves to reduce energy consumption, improves efficiency, and is at the same time good for the environment.

Introduction

A data centre today represents the heart of the IT installations in practically all companies. It is here that all important data and information are collected and stored. The demands for computing power are rising constantly in line with trends such as virtualisation, big data and services for mobile devices. Despite the many efforts to reduce IT energy requirements through a diversity of technical and planning measures, the power consumption of the individual devices continues to rise due to the increasing packaging densities and miniaturisation. As a consequence, there are at the same time ever greater heat losses to be dissipated from the installed equipment.

Energy efficiency is the declared aim of all data centre manufacturers and operators. The burdens placed on the environment by excessive CO_2 emissions are to be avoided, and – however banal it may sound – energy costs are to be kept as low as possible. According to a study conducted by the Borderstep Institute[1], the energy consumption of data centres in Germany rose from four to almost ten terawatt-hours (9.7 TWh) between 2000 and 2011. The curve flattened slightly after the “Green Energy” discussion began around 2007, and consumption was down to only 9.4 TWh in 2012. A large share of the savings was achieved through improvements to the infrastructure, especially in connection with climate control. Alongside general technical advances, significant merit can be attributed to modern cooling concepts, and there above all to heat dissipation close to the source.

The cooling of IT equipment calls for properly matched and efficient cooling solutions: They take up the thermal loads, dissipate the unwanted heat via a cooling system, and return air which has been cooled back to operating temperature to the servers. With its Liquid Cooling Package (LCP), the company Rittal offers cooling solutions with the capacity to dissipate heat losses of up to 55 kW per rack. Thank to their modular design, the equipment can be scaled up to the maximum cooling output required, and is thus also prepared for future increases in cooling requirements. LCPs are able to function so efficiently because they take up and remove the heat directly at the source. That is what distinguishes the LCP from a classic room cooling system, which extracts the whole air of the data centre under the ceiling, and then – after cooling – blows it back in front of the IT racks via a perforated raised floor.

LCPs are bayed to the side of the 19-inch enclosures in the data centre and supplied with chilled water via piping under the raised floor or along the ceiling. Heat exchangers in the units take up the hot outlet air from the servers and cool this air by way of the chilled water. The air which is thus cooled back down to the normal operating temperature is subsequently

[1] Hintemann, R. und Fichter, K. (2012): Energieverbrauch und Energiekosten von Servern und Rechenzentren in Deutschland. Aktuelle Trends und Einsparpotenziale bis 2015.

blown directly into the racks from the side, or from the front into the cold aisle containment. This arrangement provides not only for very high cooling outputs, but also – where heat loads can be spread over several LCPs – for the redundancy necessary to guarantee reliable operation.

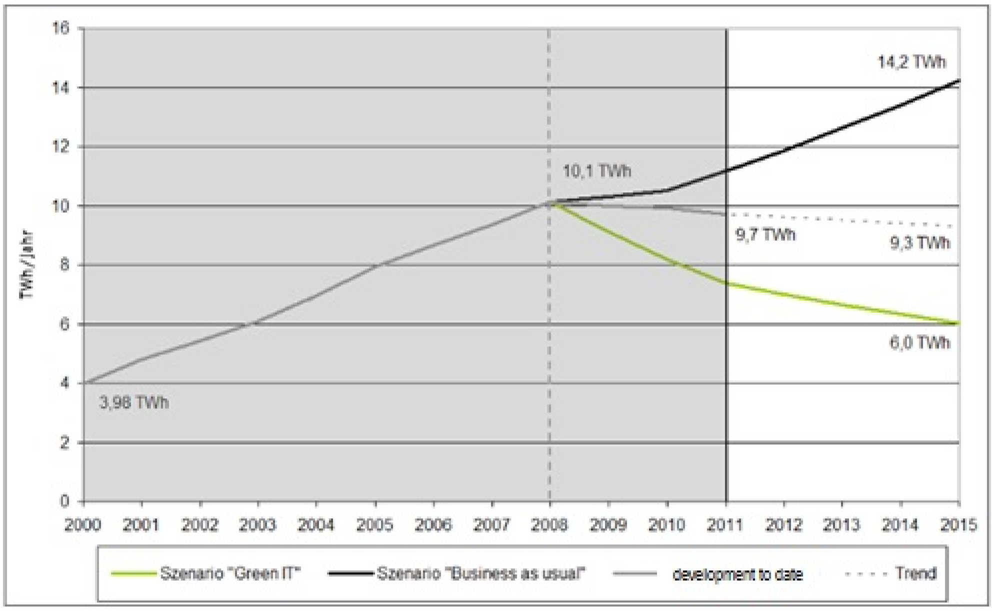

Figure 1: Development to date and scenarios for the future energy costs for servers and data centres in Germany[2]

[2] http://www.bitkom.org/files/documents/Kurzstudie__Borderstep_I_Rechenzentren.pdf.

The traditional approach: Room climate control with circulating air

Data centres with power losses of less than 5 kW per rack are traditionally cooled by way of CRAC systems. Even in modern or recently upgraded data centres, this form of cooling is still widespread. The basic principle of a CRAC system is as follows: Hot room air is extracted from just below the ceiling and cooled with the aid of a heat exchanger using either water or refrigerant as its cooling medium. Fans installed in the system distribute the cooled air under a raised floor, from where it emerges directly in front of the IT racks via perforated floor tiles and can be drawn in by the individual servers. The use of water as a cooling medium brings the advantage that indirect free cooling can be realised whenever the outside temperatures lie below the water feed temperature. This is especially cost-effective, as the water is cooled solely by the cold ambient air and no energy is required for a compressor. The compressor must only be activated if the ambient temperature increases to above the water feed temperature.

Cooling with CRAC systems becomes a challenge where IT racks with power losses in excess of 5 kW are to be cooled, or where individual racks with high power losses (hot spots) stand between racks with lower thermal loads. The difficulty here is to ensure that the appropriate volume of cooling air is routed to each rack via the raised floor. The space of the raised floor should also not be “abused” as a cable duct, as cables, cable fittings and other installation materials can massively impair the distribution of the cold air.

A further problem – which can nevertheless be solved – is mixing of the hot air with the freshly introduced cold air. This reduces the maximum possible difference between the intake and outlet temperatures (delta T), which in turn reduces the cooling output. The effect can be recognised immediately from the calculation formula $Q = m * c * \text{delta } T$, where Q stands for the cooling output, m for the mass flow of air, c for the specific thermal capacity of the air, and *delta T* for the temperature difference between the hot and cold air.

Where the mass flow of air is kept constant by the CRAC system, and the specific thermal capacity of the air similarly remains constant, the cooling output can only be raised by increasing the air-side temperature difference. In a real data centre environment, the increased temperature difference is usually achieved by providing aisle containment.

Aisle containment comprises a set of mechanical ceiling and door elements which physically enclose the space between two rows of racks. Special doors at the ends of the rows ensure that the racks, and thus the IT equipment, remain accessible at all times, as illustrated in Figure 2. There are two variants of aisle containment: Cold aisle and hot aisle containment.

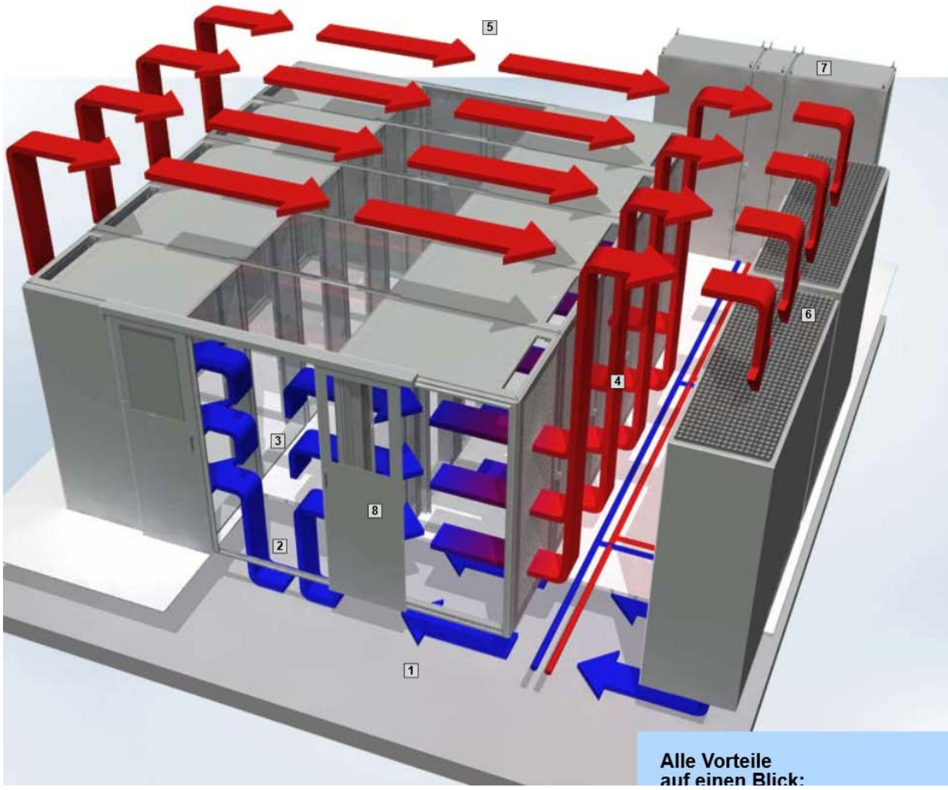

Figure 2: Function principle of aisle containment

Cold aisle containment

In the case of cold aisle containment, the enclosed space is formed between the fronts of two rows of racks. The hot air from the servers is here blown out unhindered into the open space to the rear, from where it can be extracted by the room climate control system. The cold air remains within the containment, where it flows unhindered from outlets in the raised floor and can be passed in front of the servers without the problem of mixing with hot air which is being removed from the racks. This serves to maintain the maximum possible difference (delta T) between the intake and outlet air temperatures.

The benefit of this variant is that the cold air can be supplied purposely and at the right temperature (ASHRAE recommendation: 18 - 27°C) over the full height of the IT equipment of the rack. This variant can be combined optimally with CRAC cooling systems, as the latter are able to extract the hot air directly.

Hot aisle containment

Hot aisle containment, by contrast, encloses the space to the rear of the server racks and leaves the front sides open. Hot air collects in the containment, from where it can be extracted more precisely by way of bayed cooling systems, such as Rittal's LCP Inline, and subsequently blow back in front of the racks after cooling.

Hot aisle containment is an expedient choice for large data centres where racks with high power losses are concentrated in one section of the data centre. As the particularly hot aisle is segregated by the containment enclosure, the existing room climate control system is relieved accordingly. Both cold aisle and hot aisle containment can be retrofitted in existing data centres which operate with CRAC cooling systems.

Yardstick for efficiency: The Rittal Liquid Cooling Package (LCP)

Rittal's cooling solution Liquid Cooling Package (LCP) is offered in two output classes. The smaller variant is able to dissipate heat losses of up to 30 kW, while its larger counterpart is engineered to handle thermal loads up to 55 kW. As the systems are designed on a modular basis, they can be expanded easily and thus matched to increasing cooling demands at any later date.
In their original delivery state, the units are not already configured with the maximum possible number of fan modules and thus do not yet supply the maximum possible cooling output. This helps to keep investment outlay lower at the beginning of a project. If a higher cooling output becomes necessary over the course of time, or if redundancies are to be established, further fan modules can be retrofitted without interrupting the current operation.

As the EC radial fans used are especially efficient in the partial load range, a full configuration with the maximum number of fan modules is sensible as a means to optimise operating costs.
The LCP with a cooling output of 30 kW, for example, achieves the required air throughput with three fan modules, which then run at full speed. If the maximum number of fans (six modules) is installed, however, the same air throughput is achieved with all fans running at a slower speed. This reduces the electricity consumption of the LCP by up to 40%. The system variants LCP Rack and LCP Inline, in which the LCP units protrude from the front of the rack suite, accommodate up to six fan modules per unit. Where the LCP Inline is installed flush with the rack fronts, on the other hand, a maximum of four fan modules can be fitted.

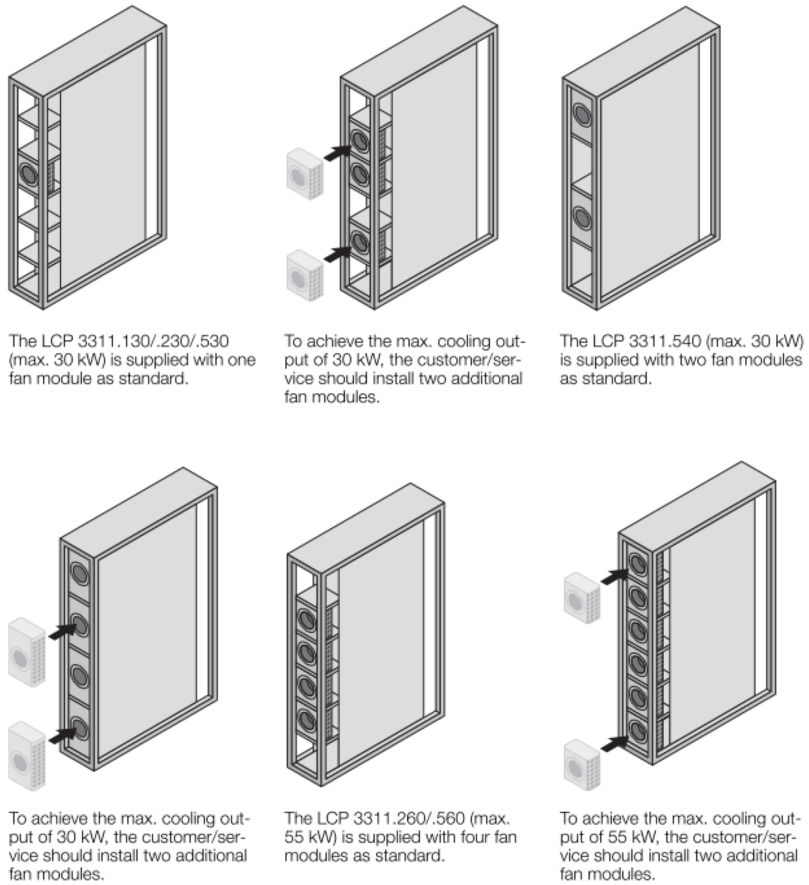

Figure 3: LCPs with different fan configurations

Generally speaking, Rittal LCPs can be classified into four basic variants, firstly by way of the cooling medium used: LCP CW systems use chilled water for cooling, whereas the LCP DX versions use a refrigerant. The second distinction concerns the positioning of the unit in relation to the IT racks. LCP Rack systems form a closed cooling system together with the server enclosures of a suite. The hot air from the IT equipment is drawn in directly by the LCP at the rear of the racks, and then blown back out in front of the 19-inch levels after cooling. An LCP Rack system thus places no additional demands on a room climate control system. LCP Inline systems, on the other hand, blow the cold air out into the front-side room space or cold aisle, from where it can be drawn in by the IT hardware installed in several server racks. The hot air is extracted either from a hot aisle or from the room as a whole. Both LCP Inline and LCP Rack are available in CW and DX versions.

The Rittal LCP CW is based on an air/water heat exchanger which uses chilled water to cool the hot air from the IT rack. The setpoint value is always the server intake air temperature, which can be chosen freely by the customer. ASHRAE currently recommends server intake air temperatures between 18°C and 27°C. The set temperature is maintained automatically by the LCP CW by adapting the water and air volumes to the actual heat losses.

Ingenious mechanical design

The water circuit is physically isolated from the IT hardware – through the separation into rack and LCP sections. The thermal energy is delivered to the heat exchanger solely by way of the air flow. Even if a leak were to occur, the electronics in the rack would not be affected. LCPs detect leaks within the unit with the aid of integrated sensors and report any defect to a technician via a safety monitoring system. Liquid Cooling Packages can be bayed with Rittal TS IT racks using standard accessories.

Assembly is extremely simple and can be accomplished conveniently both for newly planned data centres and retrofit projects. The sides of the LCPs possess sharp-toothed serration to guarantee reliable earthing of the side panel via the 19-inch rack. If corresponding baffles and air guides are fitted, an LCP can also provide cooling for installed devices which require an air flow from the side rather than from front to back. This is the case with switches or routers, for example. The water-side connections are usually realised with flexible hoses, which can be ordered as optional accessories. This solution represents a simple means to bridge the short distance between the fixed supply piping of the building installations and the water connection of the LCP.

Unlike a CRAC system, LCPs are not installed separately in the room. To enable the thermal loads to be taken up as close as possible to the source, the merely 300 mm wide LCPs are incorporated into the rack suites. This brings several advantages: In contrast to a raised-floor arrangement, the cooled air must not be routed over long distances. Pressure losses under the raised floor can be avoided, and there is additionally no premature warming through the mixing of cold and hot air. This increases the efficiency of the cooling system.

With the LCP, the air is delivered directly to the air intakes of the IT hardware, and that practically without losses. The particularly efficient and energy-saving fans of the LCPs (EC technology) distribute the air to the full height of the 19-inch racks, either directly from the side or from the front via the cold aisle. As a result, all 42 U of a 2000 mm high enclosure remain available for servers and equipment. Furthermore, the cold air is spread evenly over the full height. This means that no server is subjected to an unnecessarily higher air intake temperature, which could otherwise lead to a shorter service lifetime.

Cooling medium water or refrigerant

The electrical and water connections are realised with cables and piping under the raised floor of the data centre. Each LCP CW must be provided with water connections for the chilled and warm water. A suitable chiller, ideally equipped with a facility for free cooling, cools the warm water from the LCPs back to the required feed temperature. An LCP DX system similarly requires two connections, in this case to transport the refrigerant to and from the external condenser.

LCPs are controlled by way of a CMC III (Computer Multi Control) Processing Unit. This unit receives measurement data from the controller of the fan modules, from the sensors on the heat exchanger and from the controller of the water module via a CAN bus, applies the appropriate control algorithms, and sends corresponding setting values, such as fan speeds, back to the individual modules. The air temperature of the server enclosure is controlled by varying the fan speed and the water flow through the heat exchanger. In addition, the CMC III monitors all measurement values and triggers an alarm if limits are exceeded. The controller is also responsible for calculating the current thermal load from the feed and return temperatures, as well as the determined water flow rate. Numerous complex options can be selected via the controller to influence the control characteristics of the LCP. In this way, for example, the LCP could be set up to operate with maximum energy efficiency, or alternatively to react particularly sensitively to temperature fluctuations.

Cooling of the IT hardware is an extremely important aspect for the proper operation of a data centre. Without cooling, the servers would very quickly overheat and shut down. In today's IT-dependent business world, such server failures would entail immediate and serious consequences. Depending on the particular rack affected, it may no longer be possible to send and receive e-mails, online shops could no longer generate revenues, or else central enterprise resource planning systems such as SAP may no longer be available. To avoid such scenarios, the cooling systems, too, must be configured with appropriate redundancy. Thanks to their modular design, it is very simple to set up LCPs for redundant n+x operation. With the LCP Rack, for example, it is possible to provide two LCPs to the right and left of each rack. The actual cooling is then handled by the LCP which is active in each case, which corresponds to n+1 redundancy. Where the LCP Inline is used, several LCPs can supply cold air into the cold aisle to raise the redundancy of the overall system. Depending on the form of redundancy required, the cooling medium can also be supplied via two separate supply systems. The LCPs are connected alternately to the two supply systems A and B. If system A fails, for example, the other half of the LCPs, which are connected to supply system B, remain in operation as before.

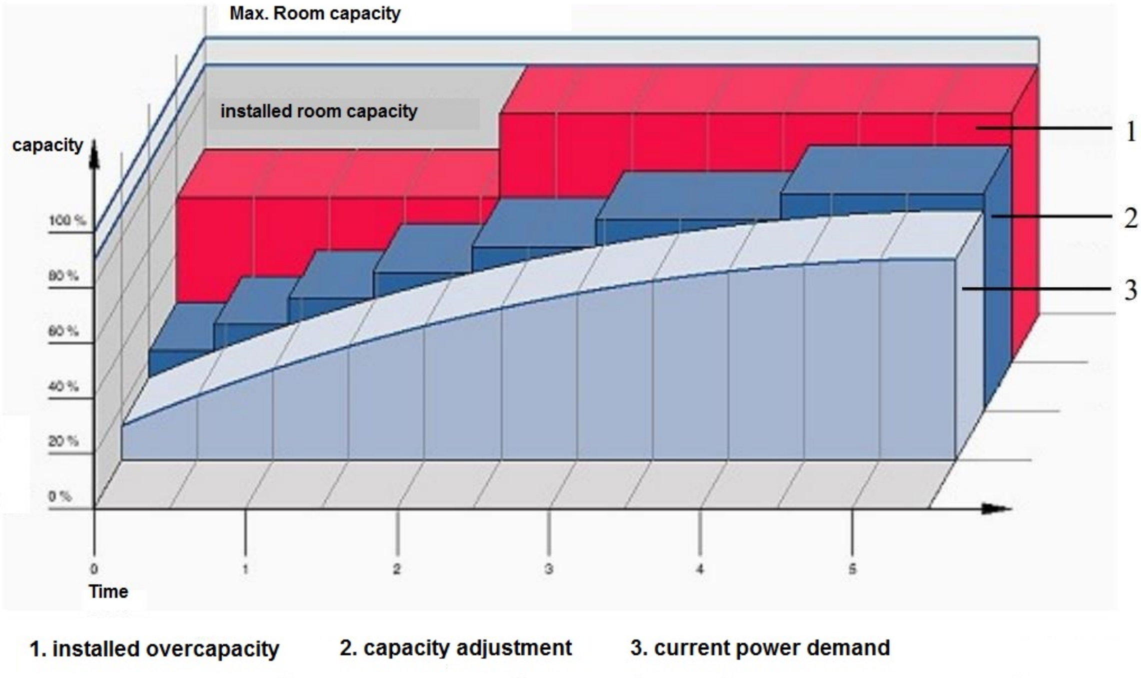

Figure 4: Optimum adaptation to changing demand levels

Suite climate control with LCP Inline

Rittal's LCP Inline provides cooling for a complete rack suite. In contrast to a CRAC system, the LCP Inline is not installed separately, but instead incorporated into the row of racks. Figure 5 illustrates the function principle: The hot air expelled at the rear of the servers is drawn in by the LCPs, cooled, and then blown back out to the front. In conjunction with aisle containment, this ensures a very efficient supply of cold air to the servers. The LCP Inline boasts a significantly higher cooling output compared to a CRAC system, despite the drastically reduced footprint. The protruding variant of LCP Inline is able to dissipate up to 55 kW per unit, and occupies an area of only 0.36 m². For suite cooling, this cooling capacity of 55 kW is typically spread over several IT racks.

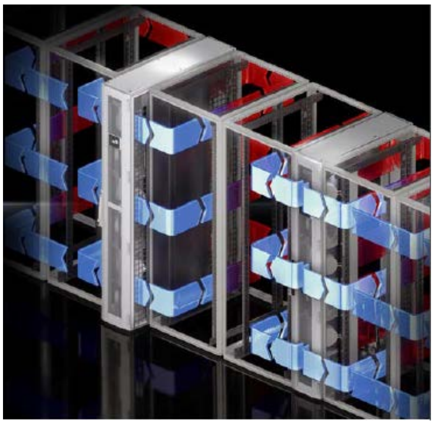

Figure 5: Function principle of Rittal LCP Inline (protruding and flush)

The LCP Inline can be integrated into a rack suite in one of two ways. Alongside a flush variant, the LCP Inline can be installed such that it protrudes into the cold aisle. With this variant, the air is no longer simply blown out to the front, and thus into the cold aisle, but is instead spread left and right directly in front of the neighbouring IT racks. This effectively produces a “cold air curtain” in front of the server racks. As the air is blown out evenly in front of the servers, moreover, the air distribution is improved and there are no routing and diversion losses. Consequently, energy input is minimised and the efficiency is increased. The protruding LCP Inline variant is available with cooling outputs of 30 kW and 55 kW.

If the customer requires a consistent aisle width, for example to maintain emergency escape routes, then the IT racks can be combined with a flush variant of LCP Inline. In this case, the cold air from the fans is diverted by 90 degrees and blown out to the front into the cold aisle. The baffles to redirect the cold air themselves occupy a certain proportion of the space in the LCP Inline, which means that such units can only accommodate up to four fan modules. For this reason, the flush LCP Inline is also only available for a cooling output of up to 30 kW.

Typical applications for LCP Inline are situations where heat losses of up to 15 kW per rack are to be dissipated. The high air volumes required are made available directly at the heat source and must not be routed via a raised floor. Experience shows that an air-side delta T of 15 K should not be exceeded when configuring an LCP Inline system, as such a set-up would no longer be practicable. The selected water feed temperature should lie above the dew point, so as to avoid wasting energy for latent cooling. At the same time, this eliminates the need for provisions to drain off condensate. Overall cooling output always comprises the components latent cooling and sensible cooling. If the water feed temperature lies above the dew point, the proportion of latent cooling is zero, as there is no condensation at the heat exchanger. The overall cooling output is thus identical with the sensible cooling output, i.e. it is used wholly for cooling of the air.

If the water feed temperature lies below the dew point, condensation forms at the heat exchanger, for which a proportion of latent cooling output is required. This share of the cooling capacity is no longer available to cool the air and reduces the sensible cooling output; the efficiency of the cooling system is reduced accordingly. In practical terms, this means that more cooling units than are actually necessary must be used to dissipate the heat losses from the data centre. The option of suite cooling is a very popular choice, both in data centres with heat losses in the megawatt range, and for smaller applications where only two rows of racks stand opposite each other. The installation of aisle containment is in these cases obligatory.

Figure 6: LCP Rack and LCP Inline (protruding and flush)

Rack climate control with LCP Rack

The Rittal LCP Rack is offered in two output classes with useful cooling outputs of 30 kW and 55 kW. It is mounted to the side of a rack. In contrast to LCP Inline, the combination of IT rack and LCP Rack constitutes an closed air circuit for cooling of the installed equipment. The air circuit within such a rack with LCP is illustrated in Figure 7. The hot air from the rear of the servers is drawn to the side by the fans of the LCP. The LCP cools this air by way of an air/water heat exchanger and blows the cold air back out in front of the servers. The cooling of the servers is independent of the ambient air in the data centre and can thus be tailored flexibly to the power losses of an individual rack. Modular expansion is similarly possible. Up to six fan modules can be fitted in an LCP Rack, enabling the cooling output to be matched to the actual demand. Over-dimensioning, and the associated higher energy consumption, are avoided effectively.

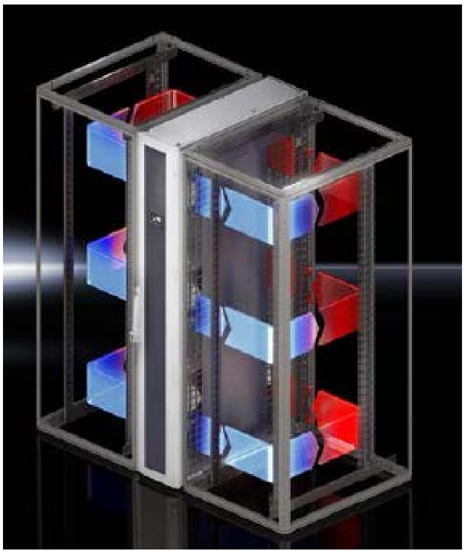

Figure 7: Function principle of LCP Rack

It is also possible to use an LCP Rack to cool two IT racks. In this case, the racks are connected to the left and right of the LCP, and the cold air is divided between the two sides. The total power losses of both racks must naturally not exceed the capacity of the LCP Rack. Redundancy can be achieved by alternating LCPs and racks in a suite. If the LCP to the left of a rack fails, the cooling can be taken over by the LCP to the right, and vice versa. The LCPs can additionally be connected to separate chilled water supplies.

A further possibility is to incorporate an automatic door opening system: If an LCP fails and the server intake air temperature subsequently exceeds a previously defined value, the rack doors are opened automatically and the full volume of air in the room can be used for emergency cooling.

Typical applications for the LCP Rack system are installations where heat losses of up to 55 kW per rack are to be expected. The high air volumes required are made available directly at the heat source. Cold air is blown in front of the 19-inch level, and the hot air is removed at the rear without the air actually leaving the IT rack. Experience shows that a higher air-side delta T of up to 20 K can be planned when configuring an LCP Rack system. Blade servers permit an air-side delta T of up to 25 K, although these data should be discussed with the operator in advance. The selected water feed temperature should lie above the dew point, so as to avoid wasting energy for latent cooling. At the same time, this eliminates the need for provisions to drain off condensate.

In practice, rack cooling is frequently the chosen option for university installations where high power losses are to be dissipated per rack, but is also to be found in automobile-related and meteorological applications, for example crash tests and weather simulations. Furthermore, there are many users who, for energy reasons, wish to cool only the specific IT racks, rather than the whole room in which they stand, and thus prefer rack-based cooling solutions. An additional advantage is that the such systems are very quiet, as both the LCP and IT racks are provided with closed doors, which reduces noise levels in the immediate surroundings. The applications encountered in the field are thus very diverse.

Figure 8: LCP Rack

Energy-efficient and ultra-compact: LCP hybrid

A further LCP variant is the LCP hybrid. Its function principle is based on the air flows which servers and other equipment already produce within the rack. The fans of the IT hardware draw cool air in at the front side of the server, switch or storage system, pass this air over the internal components and blow it out – in the meantime warmed – to the rear. Normally, the room climate control system would there extract the warmed air flow and later return it to the cooling systems.

Figure 9: LCP hybrid

With the LCP hybrid, the simple door at the rear of the rack is replaced with a combination of heat pipe and air/water heat exchanger. The air first flows via the heat pipe to achieve an homogeneous heat distribution, before passing on to the subsequent air/water heat exchanger. The air then leaves the LCP hybrid at server intake temperature and is available to the IT equipment once more. If the server racks are installed in rows one behind the other, the cold air is delivered directly to the intake of the next server enclosures. The whole data centre effectively becomes a single cold aisle, because the hot air from the servers never leaves the IT racks. A further advantage is that the LCP hybrid is able to operate with high water feed temperatures. This permits the share of indirect free cooling to be increased and thus reduces operating costs.

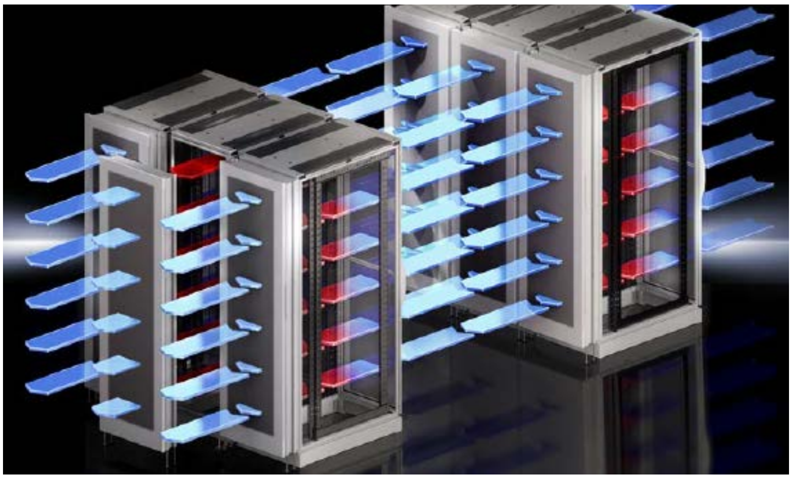

Figure 10: Function principle of LCP hybrid

As the hot air no longer leaves the IT racks, the temperature in the whole room corresponds essentially to the operating temperature of the servers. Depending on the specifications applied (ASHRAE, etc.) and the philosophy of the data centre manufacturer and operator, this temperature lies between 18 and 27 degrees Celsius. The working conditions for the staff in the data centre are improved, as there are no longer temperature differences between a cold and hot aisle. Furthermore, noise levels are reduced, because additional noise sources such as an active climate control system are eliminated. That is especially positive for the working climate in data centres where personnel must be present frequently and for longer periods.

LCP hybrid systems are provided with a fixed water connection. Opening and closing of the unit is thus unproblematic. The opening angle of the LCP hybrid is 130 degrees and permits free access to the rear of the servers and the associated cabling should this be necessary. To ensure that as much hot air as possible finds its way between the cooling coils, sealing and air baffle plates for the server enclosures are included in the scope of supply. A partition plate is fitted at the rear 19-inch rail, for example, to prevent the hot air from flowing back towards the front of the rack. The air routing can also be used to extend the cooling to equipment which expels its hot air to the side, e.g. switches with a high port density, where there is not sufficient space for ventilation slots between the network connectors on the front panel.

The cooling doors and sealing elements of the LCP hybrid can be fitted to 600 or 800 mm wide and 2,000 or 2,200 mm high TS IT Racks and are available with outputs of 10 kW and 20 kW as standard. Higher cooling outputs can be implemented upon request. Generally speaking, complete data centres can be cooled using this technology, provided the cooling systems are set up optimally. The cooling output of the units is attained with a certain water flow rate. To achieve an appropriate output for each rack, the LCPs must be balanced hydraulically. If this is done properly, each unit receives precisely the amount of water which it requires.

As an LCP hybrid possesses no active components such as fans or the like, there are no operating costs. The only costs to be taken into account in calculations are those relating to the necessary infrastructure such as chiller, pumps or indirect free cooling. If the air parameters of the cooling are to be monitored in detail, this can achieved conveniently using the Rittal CMC system with corresponding sensors for temperature and humidity. LCP hybrid systems can also be retrofitted at any time, for example as replacement for a CRAC-based cooling arrangement. The old rear door of the rack is removed and the necessary baffle plates are fitted for air routing. Existing cables should be gathered into bunches, so as to present as little resistance as possible to the air flows.

When configuring a system, it must be ensured that the humidity is controlled by way of the building climate control or else a small number of CRAC systems. The water feed temperature must lie above the dew point, as condensate management is not possible with this type of IT cooling. The IT racks should be placed in rows so that the outlet air from one rack serves as the intake air for the next. If the racks are placed back to back, there is a risk that racks with a high air output could face racks with a lower air output. In this case, heat would build up in the latter, because the hot air would remain trapped in the rack.

Autonomous cooling: Direct Expansion (DX) technology

Especially in smaller and medium-sized companies (SMEs), the IT equipment may only occupy a few racks, and these racks are often accommodated in converted storerooms. The cooling in such locations is frequently difficult, because the necessary infrastructure is not available. Many operators then attempt to realise cooling with the minimum possible outlay, for example by using fans to extract the hot air from the IT racks into the storeroom. The logical consequence is that the room is heated up accordingly, which in turn itself leads to failure of the IT equipment unless active ventilation of the room can be implemented.

Another common response is to attempt to cool these small IT applications with conventional split air-conditioning systems. These systems, however, were developed and designed to serve human comfort, and not the cooling of IT equipment. For example: Typical ceiling- and wall-mounted units do not deliver an adequate volume of cold air to satisfy the requirements of IT cooling. As a consequence, the IT equipment draws the missing proportion of cold air from the hot side, which leads to higher server intake air temperatures and a reduced service life of the IT equipment. Furthermore, these split systems, which comprise a wall- or ceiling-mounted indoor section and an external unit, are not intended for continuous operation and possess neither alarm signalling contacts nor possibilities to transmit alarms via Ethernet or the like.

Perfect solution for IT islands

Rittal's LCP DX solution, on the other hand, meets all the aforementioned requirements. The unit supplies an air flow of up to 5000 m³/h and is designed for continuous operation. It goes without saying that alarm messages can be issued via a standard alarm signal contact or an optional SNMP card. Whether for applications in extremely compact locations or for the cooling of individual rack islands of a data centre which cannot be supplied with chilled water, an LCP DX is able to dissipate heat losses of up to 12 kW. It occupies only 0.35 m² of floor space and is available in two installation variants: Rack DX and Inline DX. The compressor is accommodated in the LCP DX itself (evaporator section). Such systems are an ideal choice where only a few components need to be cooled and climate control using chilled water would be too complex and expensive. The cold air is supplied left or right to an adjacent IT rack (Rack DX) or else blown out to the front into a cold aisle (Inline DX).

The condenser of the LCP DX is an external unit with two fans, which does without all active control components. The speed of the fans is determined by the pressure of the refrigerant. There is thus no need for an electrical connection between the inside and outside units; a single-phase socket outlet for the power supply at the place of installation of the condenser is sufficient. The condenser can be mounted either on the wall or on the roof. That also serves to simplify installation, and the LCP DX can be installed and commissioned in one day in most cases.

The function principle of an LCP DX corresponds to that of a typical split refrigeration and air-conditioning system. The liquid refrigerant R410a flows to the LCP by way of copper pipes. The hot outlet air from the IT hardware warms the refrigerant such that it exceeds its boiling point and assumes a gaseous state. As a gas, it is passed to the condenser unit, where it is cooled by the ambient temperature. The refrigerant transfers heat to the environment and returns to its liquid aggregate state. The cooled, liquid refrigerant can then be fed to the LCP once more.

Cooling also for external equipment

The LCP DX is designed for continuous (24/7) use, and maintenance on the four fan modules can also be performed without interrupting operation. There is thus no need to plan downtimes for simple service assignments. Furthermore, maintenance on the LCP DX is possible without granting access to the equipment installed in the rack. That is an important point where personal data and other sensitive information are stored on the IT systems. The temperature can be controlled precisely via the display of the LCP DX, and can be set to the exact desired intake air temperature for the servers. If additional devices such as printers, photocopiers or telephone systems are installed in the IT room, the room can be cooled as a whole with the LCP Inline DX. To this end, the control mode is switched from server intake control to server outlet control. In the server outlet control mode, the defined setpoint represents the maximum permissible room temperature.

All active components of the cooling system are accommodated in the inside unit, which enables the whole system to be used without problems at outside temperatures from -20°C to +45°C. The actual output is matched as required to maintain the desired operating temperature for the servers. Stepless control provides for perfect adaptation of the compressor output, also in the partial load range. Continuous, output-based control of the compressor is possible between 3 and 12 kW. This helps to save operating costs, as the unit only uses as much energy as is necessary for cooling. Below 3 kW, the system operates in a switching mode. This results in minor fluctuations in the server intake air temperature, but is not critical for the IT hardware. For communication with the environment, the display of the LCP DX can be supplemented by integration into Rittal's data centre infrastructure management software RiZone. The administrators can then monitor the operating parameters and control the system accordingly.

Typical applications for LCP Rack/Inline DX are smaller IT installations with power losses up to 12 kW. If it is only necessary to cool the racks, and not the whole IT room, the variant LCP Rack DX is used. Where there is additional IT equipment in the room to be cooled, on the other hand, the LCP Inline DX is appropriate. As the maximum cooling output depends on the outside temperature at the place chosen for installation of the condenser, the installation location must be taken into account when configuring the system. The cooling output of 12 kW can be achieved at ambient temperatures up to 30°C. At a temperature of 42°C, the cooling output is reduced to 10 kW.

Communication and monitoring with an LCP

The LCP uses sensors to monitor and control numerous environmental and operating parameters. These include the server intake and outlet air temperatures, the cooling output and the water throughput (in the case of LCP CW). The control of an LCP can be realised locally by way of a display on the unit, or else via a web browser or management software. To this end, LCP climate control systems can be provided with an Ethernet interface. Over the network, an administrator can access the web server in the network interface of the LCP, and can there retrieve informational values or modify parameters.

As the network interface also supports the SNMP protocol, an LCP can be integrated into a higher-level network management system and thus monitored automatically. One such management system is the DCIM software package RiZone from Rittal. RiZone visualises current status values in a data centre, and provides an overview of the efficiency of the overall system. The prerequisite here is that the electricity consumption of the infrastructure is metered, thus enabling calculation of the PUE (power usage effectiveness), for example.

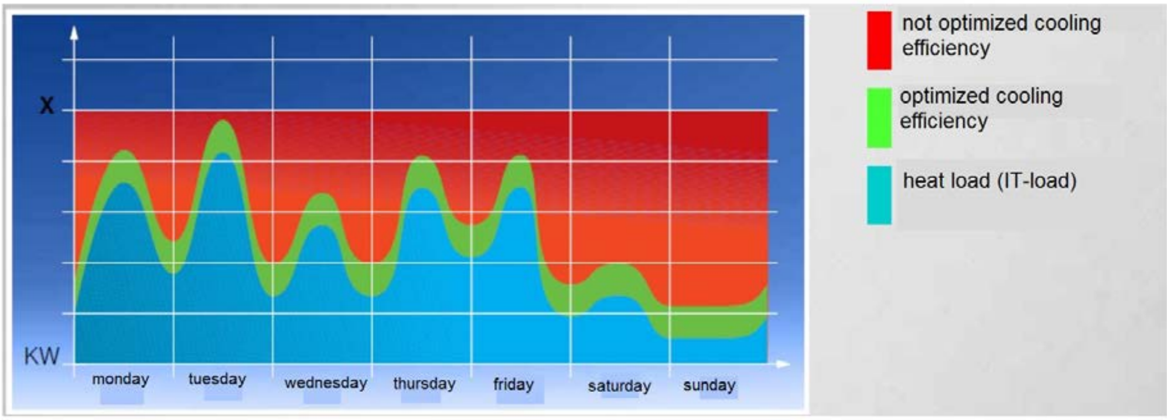

Figure 11: Optimisation of cooling output with RiZone

An integrated display is available as an option for the LCP CW. It comprises a touchscreen via which parameters can be modified and the current operating values, as well as log files, alarms and further information, can be displayed. In this way, the LCP can be set up not only via a PC, but also directly on site. The user interface implements a clear, intuitive design, which simplifies information retrieval and operation.

Figure 12 shows the main menu of the LCP user interface. It presents the cooling capacity, the temperature and any alarm or warning messages which may arise. Submenus provide access to further current values and parameter settings.

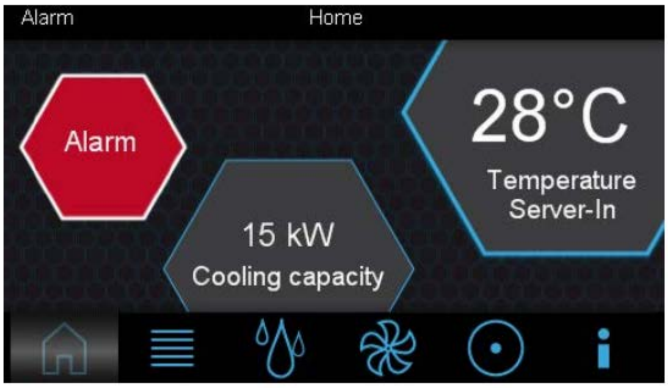

Figure 12: Main display menu with alarm

Saving with LCPs: Focus on energy efficiency

Even without higher-level management software, the design features of the LCP system already provide for very efficient operation. One important factor is the use of EC fan modules (EC = Electronically Commutated, i.e. brushless). Unlike AC fans, EC fans do not run at a fixed speed. They allow stepless speed control, and the power consumption is thus also steplessly variable (Figure 13). The modular concept, furthermore, permits more fan modules to be installed than are actually needed. This enables the speed of the fans to be reduced, the power consumption is lower, and the redundancy in the overall system is increased.

The LCP with a cooling output of 30 kW, for example, achieves the required air throughput with three fan modules, which then run at full speed. If the maximum number of fans (six modules) is installed, however, the same air throughput is achieved with all fans running at a slower speed. This reduces the electricity consumption of the LCP by up to 40%. It is similarly favourable for the service life of the fans that they are installed in the cold air zone of the LCP rather than the hot air zone. Excessive heat reduces the service life of any mechanical or electrical component. The positioning in the cold zone means that less stress is placed on the fans and their lifetime is extended significantly. Expenditure for replacements and service assignments is much more seldom than with conventional cooling technologies.

Optimum design for free cooling

LCPs still achieve high useful cooling outputs with relatively high coolant feed temperatures. Over recent years, the hardware manufacturers and data centre operators have displayed an increasing trend towards higher intake air temperatures at the IT equipment. This is thus an important aspect for cooling solutions. The high useful cooling output permits the use of free-cooling systems, wherein the cooling medium is cooled by way of the outside ambient air. The compressor must only be activated if the outside temperature is too high. In countries with cooler climatic conditions, as in most parts of Germany, indirect free cooling is possible over a large proportion of the year, provided the cooling solution is dimensioned appropriately. The operating hours of the compressor can be reduced dramatically.

For an IT installation with power losses of 100 kW, for example, up to 21% of the operating costs for a chiller with free-cooling facility can be saved if the water feed temperature is raised from 12°C (free-cooling temperature 9°C) to 16°C (free-cooling temperature 13°C). The efficiency of the data centre is improved significantly.

Even in compressor mode, the efficiency is higher. The energy efficiency ratio (EER) describes the relationship between power input, in the form of electricity consumption, and power output in the form of cooling output. A value of 5, for example, means that 1 kW of electrical energy is required to achieve a cooling output of 5 kW. The higher the EER, the more efficient the cooling system. The EER is always dependent on the operating point; the LCP DX achieves an averaged EER of approx. 3.5.

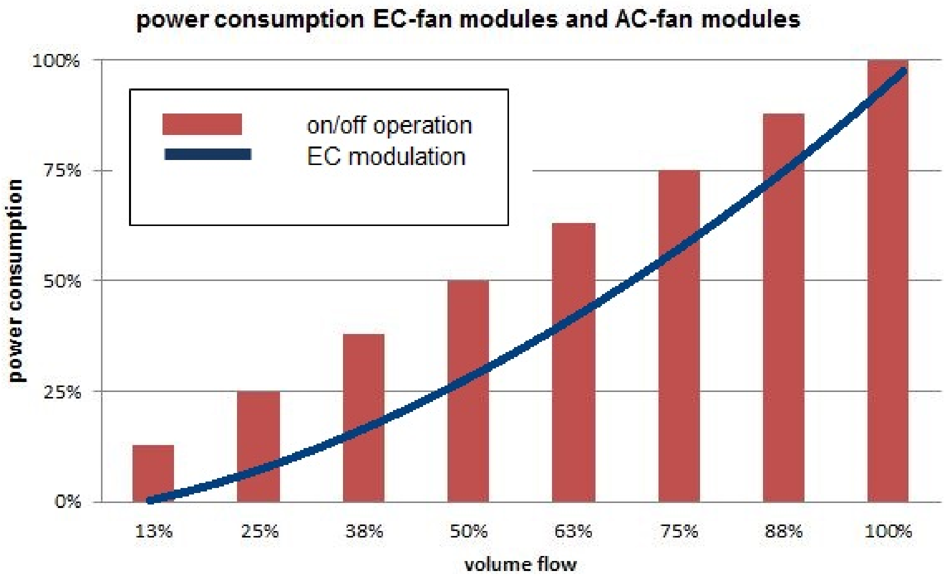

Figure 13: Power consumption of EC and AC fans

List of abbreviations

AC	–	Alternating Current
ASHRAE	–	Technical society developing standards and guidelines for the field of climate control
CMC	–	Computer Multi Control
CW	–	Chilled Water
DX	–	Direct Expansion
DCIM	–	Data Centre Infrastructure Management
EC	–	Electronically Commutated
EER	–	Energy Efficiency Ratio
IT	–	Information technology
kW	–	Kilowatt
LCP	–	Liquid Cooling Package
PC	–	Personal Computer
PUE	–	Power Usage Effectiveness
SNMP	–	Simple Network Management Protocol
TW	–	Terawatt
U	–	Height unit

Rittal – The System.

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