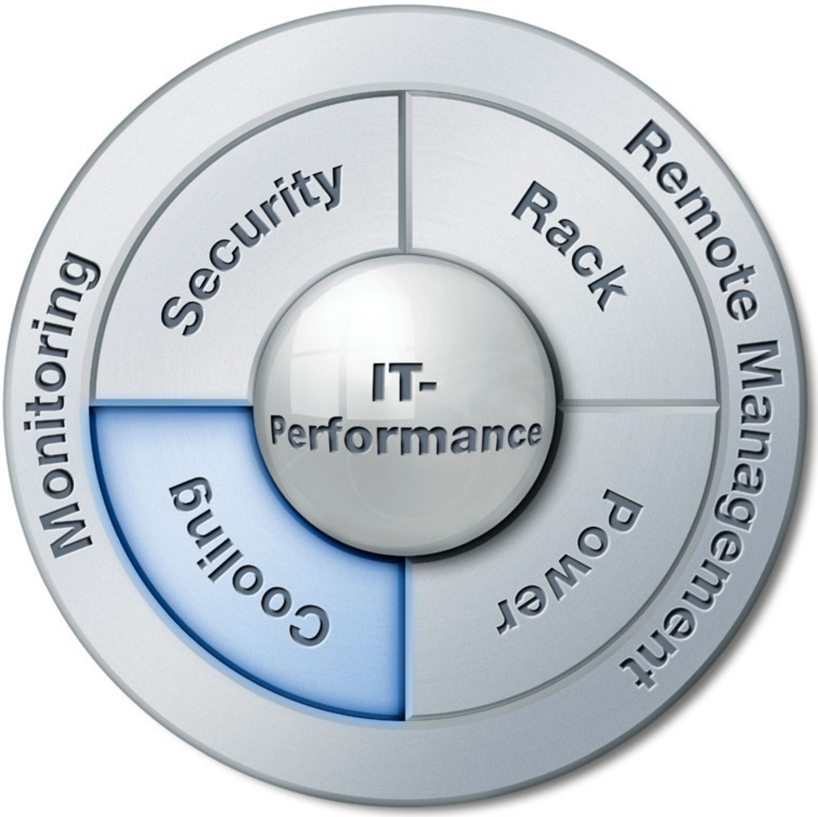
Rittal Liquid Cooling Series

by Herb Villa

White Paper 04



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Inhalt

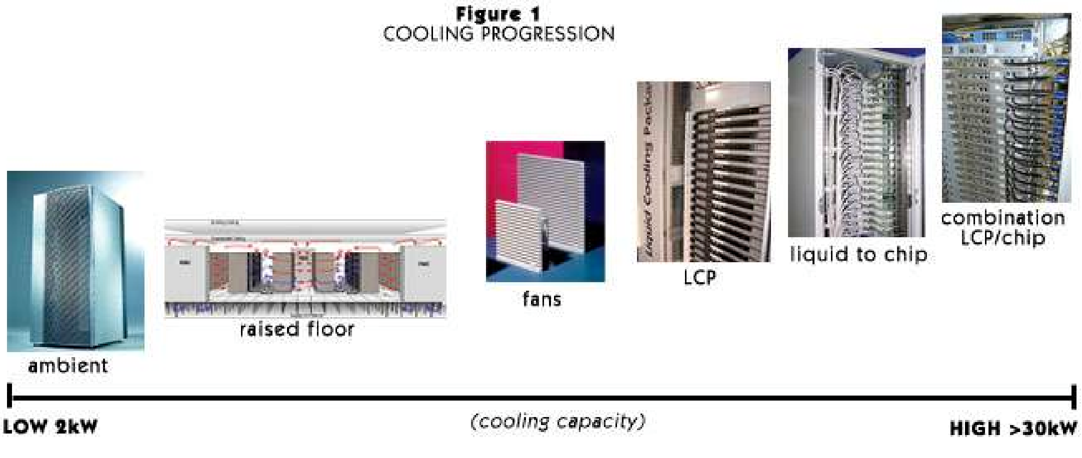
1 Executive summary

As heat densities continue to escalate, data center managers are seeking solutions for handling these extreme heat loads to protect their equipment and their facilities. This paper provides a brief history of data center cooling and explains the planning and steps necessary to implement liquid cooling with enclosure-based cabinet heat exchanger systems.

2 Alternative solutions for next generation data centers

Finding reliable solutions for removing excessive heat loads from data center enclosures is rapidly becoming the most critical issue facing the end user community. Data center managers are evaluating the most effective solutions for heat removal from equipment and facilities and many are returning to liquid cooling. But locating the proper system can be a difficult process. Type “Liquid Cooling of Data Center Enclosures” into one of the more popular online search engines and be prepared to sift through over 43,000 entries. Revising that search to “Liquid Cooling of Data Center Enclosures White Papers” still requires a review of about 14,200 listings.

Liquid Cooling Solutions are water-or refrigerant-based cooling systems, either installed directly into enclosures or mounted in data center spaces. IT managers, however, are extremely reluctant to use water (or other liquids) in data center spaces because of the risk of hardware failure due to fluid leakage. With proper planning, implementation and service, a liquid cooling solution does not have to be the source of endless, sleepless nights.



3 A brief history

In terms of a facility, water has always been present. A variety of water-cooled systems have been part of data centers for many years and remain so today. Pipes carrying chilled water often run through data center spaces, not to mention water for sprinkler systems and AC cooling. Data centers have even been located in close proximity to other spaces that use water, such as cafeterias and labs.
In the 1960s and 1970s, the first data center facilities were designed to handle large mainframe systems. Chilled water, channeled through mainframe hardware, was the only efficient way to cool the vast amount of heat generated by those systems. With far more efficient heat-absorbing properties than air, water was capable of removing 1000 times as much heat. The supercomputer systems that followed were also cooled by liquid-based systems.
Then came the explosive growth of rack-mount servers. With ambient air becoming the primary cooling medium, originally using room ambient air passing laterally through the chassis to remove heat, these servers improved network performance and capacity. Installed in rack-mount server enclosures, with front and rear perforated doors, relatively low heat loads (about 2-4 kW) per cabinet did not pose a problem for existing climate control systems.
Successive generations of servers reduced the size of individual chassis and increased processor performance, enabling users to install more units in the same enclosure, often doubling heat loads.

With the introduction of 1U multiprocessor units (two to four processors) and blade server systems, heat loads per cabinet are continuing to increase. In the last seven years, heat loads have almost quadrupled, matching the exponential increase in deployed servers. Facility managers are being asked to provide cooling capacity for 15-20 kW loads and even 30 kW configurations are being discussed. While early sites were designed to support 50 to 100 watts per square foot loads, today’s facilities need to support up to 200 watts/square foot and more. Thinking of heat loads in watts per square foot of data center space becomes meaningless at these higher heat loads. A 15 kW load in a 24” wide by 40” deep enclosure (6.66 sq ft) yields a load of 2,252 watts/sq ft. Putting this in a larger cabinet (24” wide by 48” deep, 8 sq ft) reduces the load to “ONLY” 875 watts/sq ft (see figure 4). Clearly, traditional ambient air-cooled solutions cannot sufficiently handle these extreme heat loads. Even if heat could be evacuated from enclosures, that much heat in a limited amount of floor space would overwhelm CRAC capabilities, pointing once again to the need for liquid cooling solutions.

Figure 2

4 Liquid Cooling solutions

Liquid Cooling Solutions are available in liquid-to-chip and cabinet-level cooling units. At the processor level, the traditional air-cooled heat sink is replaced with a chip-sized heat exchanger (similar to a radiator). The cooling liquid, typically a dielectric solution, is directed through a tube to the heat exchanger and the heated liquid is removed through a separate tube. A vertical distribution manifold provides connections for fluid paths from each server, as well as hot and cold paths to a chiller system. These processor-based systems are usually provided directly by server manufacturers. These systems are not suitable for retrofitting and require significant advance planning prior to installation of the first server.

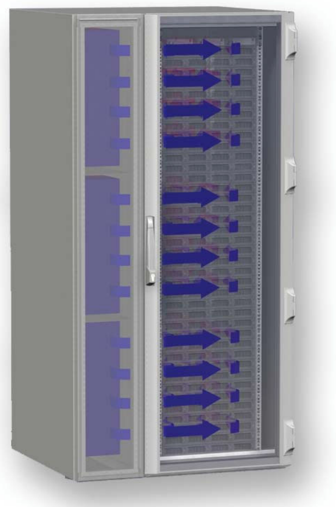


Figure 3

Rather than supplying chilled liquid directly to individual servers, enclosure-based cabinet heat exchanger systems (Liquid Cooling Package LCP, see Figure 3) provide cold air to an entire enclosure. Building chilled water supplied to the system provides the cooling capacity with a separate warm water return to facility-chilled water plants. The LCP system acts as a cabinet-sized heat exchanger with all the heat from the enclosure transferring to the water. Depending on building chilled water inlet temperature and the temperature rise across the servers, an LCP system can cool from 12 to 20 kW per cabinet with one system and up to 35 kW with two LCP systems supplying cold air to a single enclosure.

If such needs seem out of the realm of possibility, consider the following:

Servers/Processors	Heat Load	24" W x 40" D	24" W x 48" D
Six IBM Blade Centers with 84 HS 20 blade servers installed in a single cabinet	51,180 BTU/hr (15 kW)	2,252 W/sq ft	1,875 W/sq ft
HP Proliant DL 145-G2 1U servers, each equipped with two AMD Opteron processors	2,300 BTU/hr (674 W)	NA	NA
With 42U enclosures loaded to 75% capacity (32U)	73,000 BTU/hr (21 kW)	3,153 W/sq ft	2625 W/sq ft

Figure 4

So even with current generation rack-mount and blade servers, heat loads of 15-20 kW can be easily reached. With these loads well over the capacity of standard data center cooling systems, an LCP system will quickly become the only viable option.

In addition to removing greater amounts of heat from enclosures, LCP systems also benefit sites that are operating near, at or over their thermal capacity. As stated above, the heat from the enclosure is removed with the water; none (or at least very little) of the heat is rejected into the pace. Consider the following hypothetical scenario: In a room that is close to maximum cooling capacity, several enclosures with low heat loads (3-5 kW per enclosure) are to be retrofitted with blade servers, increasing heat loads to 15-18 kW. The existing CRACs cannot handle this extra heat. An LCP installation will accommodate the additional capacity and even reduce the heat
load for the rest of the facility. Even for one or two enclosures, the original 6-10 kW of heat from those cabinets is now eliminated, adding cooling capacity to the space.

5 LCP design and implementation

Great care must be taken to ensure that liquid-cooled enclosures can be deployed in existing and future data centers with minimal impact to existing facilities. Of course, these systems must be leak proof with dedicated control and monitoring systems. They must be reliable, expandable and flexible enough to allow easy reconfiguration in a dynamic data center space. Nonconductive, clean liquids should be used to eliminate the potential for equipment degradation and damage. LCP systems do not have to be deployed throughout an entire data center. End users are looking to “cluster” their extreme heat load systems in only a small area of the center. There will always remain a need for enclosures to support low-density installations, legacy equipment and network and termination components. For these applications, the traditional air-cooled rack-mount server cabinet, with fully perforated doors front and rear, will meet requirements. Building-chilled water supply lines and warm water return lines should be installed to support these cooling systems.

Supply and return lines can be installed to provide an appropriate level of redundance required for the installation (see Figures 5 and 6). Sufficient floor space should be provided to allow for the extra footprint required by the LCP system. And enough power should be brought in to supply the increased electrical demands of these high-density installations.

Figure 5

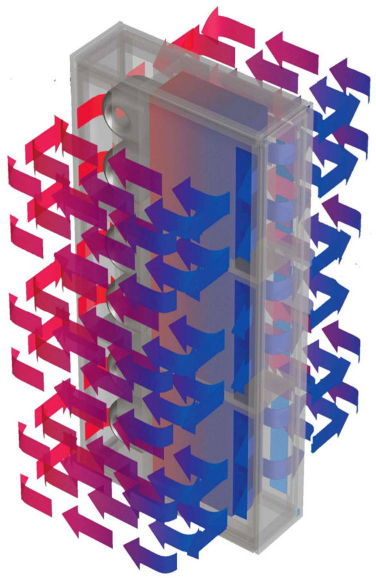


Figure 6

To install LCP systems, design engineers must start with adequate floor space. For side-mount or rear-door systems, additional clearance must be provided so that components can be installed while still maintaining aisle space and accessibility. Side-mount systems will require an additional floor space alongside each enclosure. Rear-door mount systems will need an additional 8-10 inches of aisle clearance and room to swing open a wider door, usually 30-32 inches in width. The overall enclosure depth should be at least 40 inches in order to install rack-mount servers with enough space to provide adequate airflow paths to server air intakes. LCP enclosures should also be placed in data center spaces in close proximity to water supply and return lines. Additional piping runs should be minimized as much as possible. With all physical plant systems in place, the task of installing LCP enclosures is relatively straightforward. If new pipe runs are required, these must not interfere with already installed connectivity or power cables, under-floor airflow paths or cable routing systems (i.e. cable tray).
LCP systems can be installed in non-raised floor environments. However, to avoid any possible issue with dripping water, supply and return, piping should be installed in raised floor spaces. Access to these spaces must facilitate installation of attachment points to piping for connection to LCP systems. Additional floor tile cutouts will be required to feed connection hoses to LCP modules. Separate electrical circuits should be available to provide power to LCP modules. And, if required, network connectivity points should also be available to provide monitoring and control capabilities of the LCP system.

Finally, if installed in existing data center enclosures, it may be necessary to retrofit solid doors (viewing or solid steel) and a solid roof to the enclosure. It will also be necessary to seal or close all cable entry penetrations into the enclosures to be liquid cooled. This is critical to ensure that all cold air is delivered to server air intakes and no warmed exhaust air is dissipated into data center spaces.

6 The future is now

Higher heat loads in individual enclosures and facilities are demanding alternate cooling solutions to ambient air, which is quickly reaching its heat removal limit. As liquid cooling gradually moves into the mainstream, data center managers must prepare to support liquid cooling solutions with careful consideration given to:

- Environmental considerations including existing floor spaces, water supply and available power
- Equipment requirements to manage liquid at the cabinet or microprocessor level
- Cabinet and hardware selection that best supports liquid cooling
- Quantifications on liquid cooling benefits in terms of component performance, data integrity, floor space savings, data center scalability and resulting ROI

With the proper education, planning and implementation, liquid cooling will provide efficient cooling for data centers, now and for years to come. With ever increasing heat loads looming on the horizon, liquid cooling is the best choice for data center heat removal needs.

7 Conclusions

With careful planning and implementation, liquid cooling cabinet heat exchangers (LCP) are an ideal solution for removing excessive heat loads from the data center. Among the considerations for implementations of LCP systems listed above is the logistics of placing enclosures in close proximity to water supply and return lines. To avoid any potential dripping water, supply and return piping needs to be installed under floor spaces and access floor cutouts are needed to connect hoses to LCP modules. Data center managers also need to allow for sufficient floor space for the LCP systems, as well as the additional power that will be required. They should also plan for adequate aisle space and accessibility to equipment after the liquid cooling systems are installed. Network connectivity points should also be available to provide monitoring and control capabilities of the LCP systems.

8 About the author

Herb Villa is the Field Technical Manager (Datacomm Group) for the Rittal Corporation for the US. A mechanical engineer, he has more than 17 years of experience in the data communications industry. He has been involved in all aspects of system design, installation and support, which allows him to see data center projects from three unique vantage points ~ manufacturer, installation and supplier.