Solution Brief
RackChiller

nVent HOFFMAN

CONNECT AND PROTECT

Data Centers: Meeting the high-density liquid cooling needs in the connected world

With the rapidly expanding use of high-performance computing (HPC), hyperscale, enterprise and edge applications, data center managers globally have increasingly turned to liquid cooling solutions to protect powerful IT Equipment (ITE), while maintaining high availability at minimal operational costs. Now, as the power/heat generation of high-performance processing chips pushes past the cooling capabilities of air solutions, liquid cooling is becoming their best – and, for the foreseeable future, only – option for energy efficiency, space constraints, water usage restrictions and harsh edge environments. As a result, there is a pressing need for a flexible and reliable coolant distribution unit (CDU) solution that can be quickly implemented across a range of different applications.

This solution brief shares insight on the growing demand for high-density liquid cooling solutions, and how nVent conducted extensive voice of customer research and lab testing to deliver the industry's most advanced UL-certified CDU to precisely meets data center application needs globally.

OVERVIEW OF HIGH-DENSITY LIQUID COOLING SOLUTIONS

Compared to its air cooling predecessors, liquid cooling has only recently come into its own as the go-to standard for high-density, high-performance applications. Historically, many data center managers relied on air cooling solutions to cost effectively manage temperatures, and deployed liquid cooling solutions on a rare as-needed basis. However, this approach is becoming less feasible in high density data centers, as heat loads increase and densely configured server racks impede air circulation. For data-processing-rich applications (e.g., content, cloud computing, industrial automation, real-time modeling, etc.) close-coupled and direct-to-chip liquid cooling systems offer effective solutions for achieving required temperature parameters and lowering energy consumption of the cooling system, thus lowering operating costs.

Because it is denser than air, liquid provides a much greater heat transfer capacity – 35 times higher than that of air. Subsequently, direct-to-chip in which a cold plate is placed directly on processors inside the server presents some of the highest efficiencies. The cold plate has internal micro channels and an inlet and outlet through which liquid is circulated to carry away heat. Low-profile cold plates used in direct-contact liquid cooling also have the advantage of increasing server density in each rack.

CDUs monitor and control the system's pressure, flow and filtration, and are comprised of a liquid-to-liquid heat exchanger, pump and control system. Because CDUs are considered expensive to build and are generally custom-ordered on an as-needed basis, manufacturers traditionally do not test them before installation. Rather, they design the unit based on theoretical heat exchanger performance data variables using CAD drawings, aiming to achieve a margin of error up to 10% once implemented. For reference, the margin of error usually comes down to flow, pressure and heat capacity. So, for example, if a CDU has a maximum flow of 400 liters per minute, but can only deliver 8 psi of pressure at that maximum flow rate, then the customer might need 13 psi. In this case, the CDU might only be able to provide 350 liters per minute at 13 psi. That being the case, the solution has been to underquote the performance of the CDU and overdesign the data center facility infrastructure to ensure there is enough capacity.

In the lab test at a high-capacity heat load testing facility, the CDU was connected to the heating and cooling infrastructure to test its performance.

To this end, historically, CDU designers erred on the conservative side to help ensure a unit will achieve the desired performance, and post-deployment conducted more in-depth performance testing to better define the CDU performance for future installation sizing and performance estimates. Vendors took this approach largely because they did not have access to the significant heating and cooling infrastructure needed to conduct performance testing during design stages. However, especially as the need for high-density liquid cooling increases, this approach creates several pain points in terms of time and resources, including:

- The end user must make a business case to invest in a concept without empirical evidence it will function as planned, and unable to accurately forecast operating expenses or energy consumption.
- Custom-building a major component for each application usually takes more time and resources than deploying a standard product.
- As a hedge, the manufacturer usually will overengineer and oversize the CDU, costing the end user more capital expense without necessarily optimizing the operational capacity of the solution.
- With pressure to get the system up and running, generally a performance margin of error of 5-10% is accepted, a wide threshold potentially representing hundreds of thousands of dollars in energy for the budgetary better or worse.

Data center managers need a more predictable and reliable CDU for high-density liquid cooling. Understanding this, the nVent HOFFMAN engineering team focused on designing a wide-ranging CDU that could support virtually any installation base at efficient levels. To do this, nVent sent beta versions of its in-development CDU in succession to three different external labs with sufficient heating and cooling infrastructure to test its performance.

DELIVERING THE NEXT-GENERATION CDU

Utilizing organizational knowledge gleaned from more than a decade building standard and custom rack/row liquid cooling products, as well as feedback from participating early adopters and empirical data from third-party lab test results, the nVent engineering team systematically refined the performance, heat exchange, flow and pressure delivery of the company's first-generation platform to ultimately deliver a new industry benchmark: the nVent HOFFMAN RackChiller CDU800.

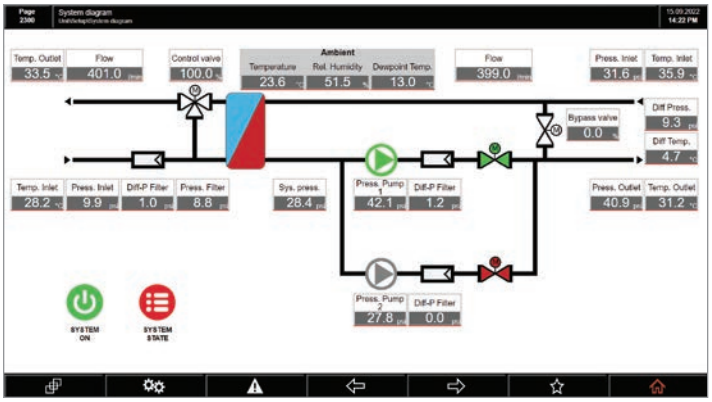
A standalone rack, the RackChiller CDU800 can be deployed next to the IT racks, or in another room away from the IT, such as to limit the amount of liquid/water in the room housing the IT systems. The CDU800 is responsible for monitoring and controlling the overall system pressure, flow, and temperature. It also monitors the filtration pressure. A facility manifold manages liquid distribution between the CDU and any number of IT racks, while the rack manifold further distributes liquid within the rack to any number of IT systems and cold plate loops.

Uniquely tested and compliant with UL, the CDU800 consistently delivers liquid coolant to maximize cooling efficiency, while taking up very little data center floor space. It also reliably removes heat from sensitive equipment through a constant cycle of pumping and heat exchange. Importantly, because of the validated empirical data gleaned through the product development and global testing phases, the performance of a given application can be accurately calculated within a 1% margin of error – mitigating the budgetary planning guesswork for data center managers.

Designed for reliability, availability and serviceability for close-coupled and direct-to-chip applications, the CDU800 provides 800 kW of liquid cooling capacity at 6 K approach temperature, and delivers high-performance liquid flow, pressure delivery and heat dissipation within a standard IT rack footprint. The platform is designed with N+N redundant pumps that provide up to 950 liters per minute secondary flow and 46 psi (3.2 bar) differential pressure. It also includes a smart control system that continuously monitors over 35 integrated sensors. This combination, coupled with low approach temperature throughout the operating range, eliminates the need for costly chiller support and enables up to ASHRAE W45 warm water liquid cooling of high-power IT systems. The pumps, sensors and filtration system are serviceable without incurring downtime or performance impact during operation.

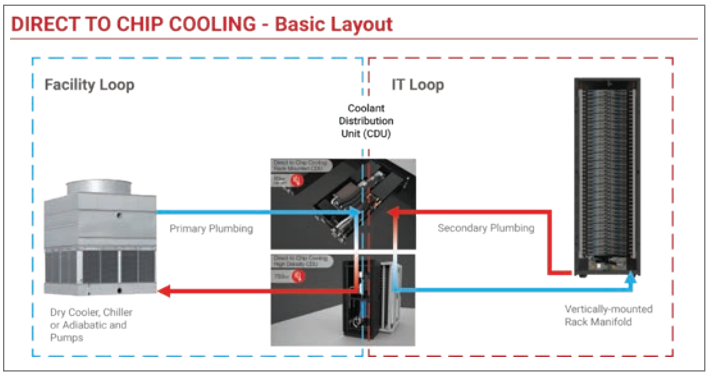
The main purpose of a coolant distribution unit (CDU) is to provide a steady flow and temperature of coolant to a variety of devices under changing operational conditions.

The complete system is integrated into an aesthetical enclosure with a 10-inch color touch display, removable side panels and doors. The CDU can install onto a slab or raised floor, in row with IT equipment racks or into a separate facility room. With this flexibility, the CDU can be installed in any environment and connected to facility plumbing with no need for modification. In addition, the system is fully enabled for remote access control, enabling true remote/lights out operational capabilities.



The 10" color display on the CDU provides easy access and visibility to the system functions, settings and current run-time parameters of critical sensors.

Furthermore, nVent has expanded its own lab capabilities to include 750 kW of thermal heat load to be able to perform future testing and simulation of customer sizing requests. This lab setup also offers the capability to test different failure scenarios to further refine the product design and help demonstrate reliable overall system function in field deployments. All of this is completed before deploying the CDU at the customer site, which effectively reduces site installation and commissioning time. Knowing the exact performance, heat transfer and functional response ahead of the installation prevents CDU overdesign and "stranded capacity," so customers get the solution they need.



Example of a basic layout for direct-to-chip cooling.

Now, data center managers can confidently weigh investment decisions and deploy high-density liquid cooling solutions that perform precisely as expected.

For example, in one recent case, a data center manager at a European automobile manufacturing facility aimed to figure out the cost-benefit analysis of investing in a new cooling solution short-term versus paying higher energy expenses long term.

Leveraging the CDU800's comprehensive test performance results, the nVent team calculated the cost-advantage inflection point of investing in various liquid cooling configurations. The data proved the a direct-to-chip liquid cooling solution with the CDU800 in-row would offer the data center the best business case, because it allowed the facility to run warmer water through the system, thus saving on the cost of using chilled water.

Next, the nVent team demonstrated the various direct-to-chip scenarios to meet the unique system level liquid cooling requirements, while reducing total cost of ownership and facility operating expenses.

In addition to the flexibility the CDU800 offers, its proven performance, built-in redundancies and smart control system optimize operation and ease of maintenance.

The data center manager successfully leveraged the demonstrated calculations and schematics to gain approval internally to invest in the optimized thermal management solution.

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BEST-IN-CLASS PORTFOLIO

nVent has manufactured data center high-density liquid cooling solutions for more than a decade. The CD800 extends the liquid cooling portfolio of integrated cooling infrastructure and makes nVent a one-stop shop for liquid cooling products. nVent offers a comprehensive range of standard and customized air, indirect and direct water-cooling solutions to protect IT assets, whether for smaller decentralized edge computing, harsh environments or large data center installations. The product portfolio includes:

- Air-to-liquid, liquid-to-air and liquid-to-liquid cooling
- Rack/row coolant distribution units (CDU)
- Rack and secondary fluid manifolds, as well as hose assemblies
- Immersion cooling

Across its nVent HOFFMAN, nVent RAYCHEM and nVent SCHROFF brands, nVent offers the most complete and innovative thermal management solutions for a variety of applications to meet equipment protection needs. From standard fan assemblies to air conditioners, heat exchangers, liquid cooling, leak detection, and more, customers can choose from more than 2,000 UL®-certified products for reliable operation and longer life of protected components.

ABOUT NVENT

nVent is a leading global provider of electrical connection and protection solutions. We believe our inventive electrical solutions enable safer systems and ensure a more secure world. We design, manufacture, market, install and service high performance products and solutions that connect and protect some of the world's most sensitive equipment, buildings and critical processes. We offer a comprehensive range of enclosures, electrical connections and fastening and thermal management solutions across industry-leading brands that are recognized globally for quality, reliability and innovation. Our principal office is in London and our management office in the United States is in Minneapolis. Our robust portfolio of leading electrical product brands dates back more than 100 years and includes nVent CADDY, ERICO, HOFFMAN, RAYCHEM, SCHROFF and TRACER. Learn more at www.nVent.com.

Our powerful portfolio of brands:

CADDY ERICO HOFFMAN RAYCHEM SCHROFF TRACER

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