DataCenter Knowledge

TOP TIPS

Liquid Cooling: A Must for High-Density Data Centers

Data centers are heating up. Organizations now use high-density server racks to support artificial intelligence, machine learning and data-intensive workflows. This means traditional air-based cooling systems are reaching their limits, causing overheating and increasing downtime.

Organizations have turned to liquid cooling for these high-density deployments. Liquid cooling uses water-based or dielectric fluids to draw heat away from infrastructure components. This helps organizations run high-density servers more reliably and ensure that they stay within the necessary temperature ranges at a cost-effective scale.

Here's a look at traditional air-cooling options, how they compare to liquid cooling, and what to consider when upgrading to liquid cooling.

Current Air-Based CoolingOoptions

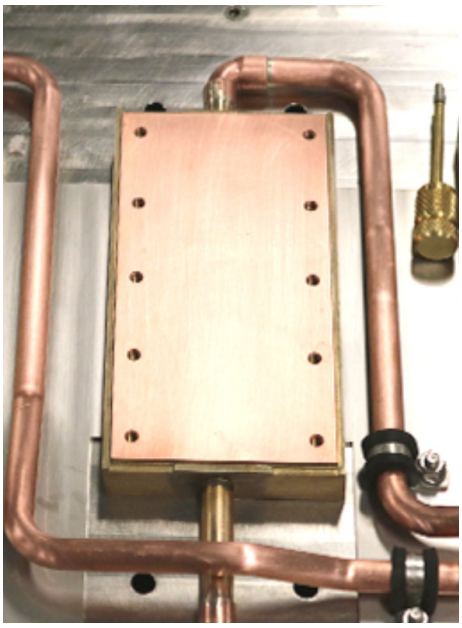
Air-based cooling offerings come in two main form factors: rack-level and facility level. These setups circulate cold air to dissipate the heat the servers generate. Still, these systems increase overall energy use, using 50% of overall building energy.

Rack-level setups, such as a rear door heat exchanger, provide local cooling to server components. Mounted directly to the server racks they offer energy efficiency, short cooling paths, and quick heat dissipation. However, it requires ancillary infrastructure like chilled water routing, becomes costly at scale, and increases overall complexity depending on the number of rack-specific requirements.

Facility-level cooling setups, or computer room air conditioning (CRAC) or computer room air handling units (CRAH), are more traditional compared to rack-level cooling. They can operate with or without raised floors and are designed to cool larger air volumes. However, they often suffer from lower energy efficiency. Managing such systems requires additional infrastructure, including air filtration and humidity control devices, to maintain stable conditions across the shared air volume and keep critical infrastructure running reliably.

The biggest drawback for air-based cooling is its density limitations. Once organizations use servers that run over 50 kW per rack, air-based cooling will no longer be practical. This may require retrofitting to run liquid cooling setups. Organizations can find rack-

level or facility-level cooling solutions on the market – but should work with an experienced thermal management company like Advanced Cooling Technologies (ACT) to ensure proper installation.



Going Farther with Liquid Cooling

Liquid cooling technology is becoming the status quo as more organizations require cooler, high-density data centers. It supports high-density server racks and is better suited for servers that run compute-intensive workloads such as machine learning or data processing. The main benefits are:

1. Energy efficiency
2. Improved performance
3. Long-term cost savings
4. Scalability

To get these benefits, organizations can choose one of two setups: single-phase or two-phase liquid cooling. Single-phase cooling uses water-based coolants to draw heat away from components. The servers continuously get liquid through a coolant distribution unit (CDU) that exchanges the heat from the servers with the facility water in the data center.

Two-phase cooling uses dielectric fluids that are pumped to the heat generating components in liquid phase and then evaporates as it removes the heat from servers. The vapor is then pumped back to a CDU where it is condensed back into liquid and is reintroduced into the system.

While thermal resistance can vary depending on heat flux and cold plate design, at the chip level single phased water-cooled solutions have experienced thermal resistances between 0.02 and 0.05 C/W, while dielectric two-phase liquid cooling has achieved results closer to 0.01 C/W, according to ACT.

The main implementation methods for liquid cooling are direct-to-chip, immersion cooling, and rear-door heat exchangers.

- **Direct to chip:** Brings the cooling system directly to heat-producing components (such as a CPU or GPU) and utilizes cold plates to exchange heat between the chips and the fluid.
- **Immersion:** The entire server is submerged in dielectric fluid which is circulated to remove heat from the system.
- **Rear door heat exchangers:** Runs liquid through an air-to-liquid heat exchanger attached to the back of server racks to draw heat out the air exiting the server blades before exiting the rack.

Data Center Cooling Considerations

Though thermal effectiveness varies depending on the specific data center, liquid cooling has led to a more than 15% increase in Total Usage Effectiveness and a 10.2% decrease in overall data center power, according to Vertiv. Liquid cooling options are also more scalable than air cooling options and lower overall energy usage.

Before organizations decide to invest in liquid cooling, they should be aware of the initial upfront cost, potential for liquid leaks, and having staff on hand that can run these systems. The main considerations are:

Cost: Even though liquid cooling is more effective at cooling infrastructure, there can be high upfront costs to either build or upgrade data center systems. Organizations should perform cost analysis to see if any upfront costs are worth the long-term investment as well as power and water pricing.

Leaks and leak detection: A leak of a water-based fluid can be damaging to electrical components. Organizations should work with a thermal management firm to confirm what leak proofing methods they provide and recommendations for potential detection software.

Futureproofing: Organizations should have staff that can currently run their cooling infrastructure and help build out a knowledge base for future employees. These systems require different skills and knowledge than air-cooling systems, such as working with dielectric fluids and proper cleaning methods.

Conclusion

As more organizations look to run complex, high-density workloads, they will require cooling infrastructure to support their data centers. Though air cooling has worked in the past, it's now becoming apparent that liquid cooling is necessary – and more effective – to cool high-density workloads.

With the right research, service providers like ACT, more organizations can effectively implement the technology. This will lead to a more energy efficient data center that can run specialized workloads without overheating.