APPLICATION BRIEF

Graver Technologies

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AB-009

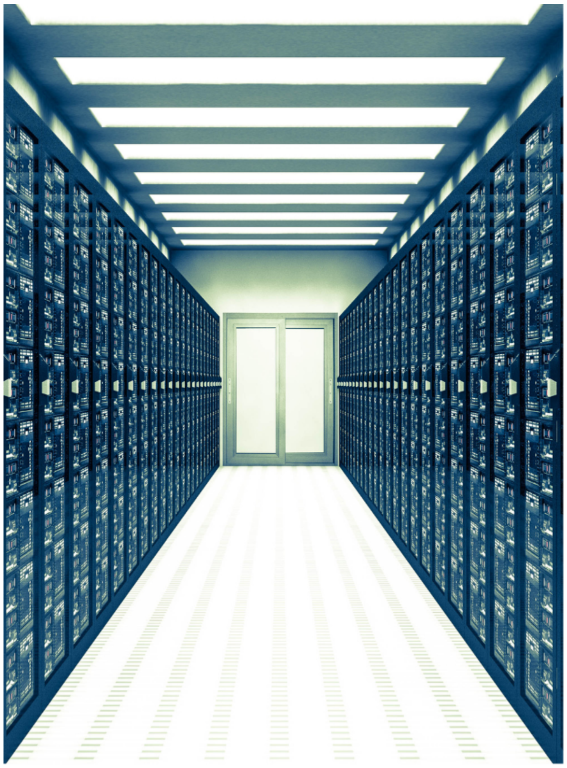
Importance of Filtration in Data Center Cooling Water Systems

Overview:

Modern data centers rely heavily on water-based cooling systems—such as cooling towers, chillers, and liquid-to-chip loops—to manage rising server heat loads. Without effective water filtration, these systems are vulnerable to fouling, scaling, corrosion, and microbial growth. These issues degrade system efficiency, increase operational costs, and can lead to unplanned downtime.

The cooling process, which requires a large air-water interface, is especially prone to four major water treatment issues: corrosion, fouling, scaling, and microbiological activity. Suspended solids from these processes reduce heat transfer efficiency, resulting in higher energy costs. They also contribute to premature degradation and corrosion of system components, shortening equipment lifespan.

Filtration plays a vital role in maintaining clean, efficient, and reliable water-based cooling systems that meet performance, sustainability, and uptime targets.

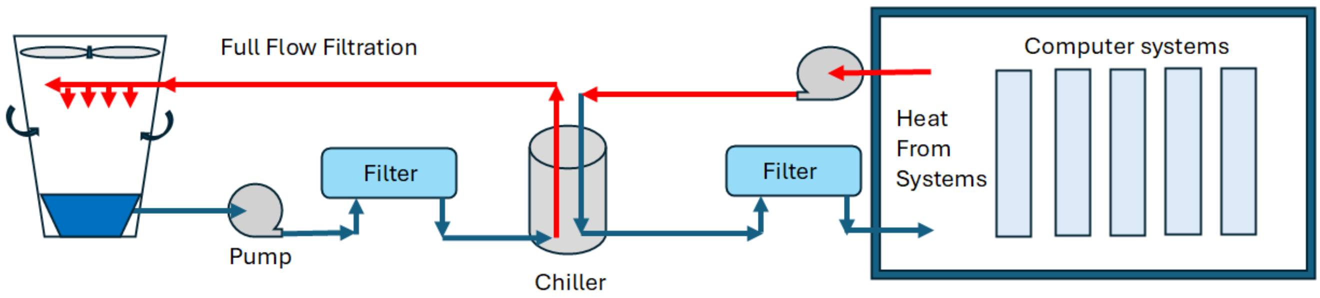


Application Information

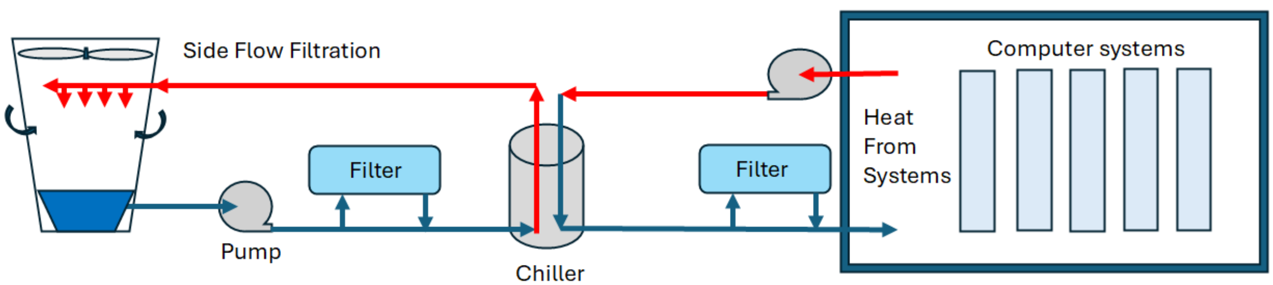
Regularly maintained filtration systems help ensure long-lasting equipment, allowing data centers to operate smoothly without frequent part replacements while yielding cost savings. Proper filtration supports robust and reliable cooling tower operations, safeguarding data center infrastructure.

Contaminants such as dirt, debris, biological growth, and scaling (from minerals and salts) can be effectively removed through mechanical filtration. The two main filtration methods for recirculating systems are full flow and side stream filtration:

- Full Flow Filtration: Installs a filter downstream of the cooling tower, accommodating the entire volume of recirculating water. Although effective, it requires high capital investment and a large footprint.



- Side Stream Filtration: Filters a small percentage (as little as 3%) of the total water flow. This method is more cost-effective, with a smaller footprint and reduced operational costs. It also allows offline cleaning of filters, minimizing system downtime.



Application Challenges

- Particulate Fouling: Dirt, sand, silt, and debris clog pumps, valves, and heat exchangers.
- Scaling: Calcium, magnesium, and silica ions cause mineral buildup that reduces heat transfer.
- Corrosion: Unfiltered water can accelerate chemical degradation of metals.
- Biofouling: Warm water environments promote bacterial growth and biofilm formation.Chemical Inefficiency: Unfiltered water leads to unstable pH and conductivity, reducing the effectiveness of treatment chemicals

Filtration Solutions

Liquid filtration in cooling towers plays a vital role in maintaining efficiency and reducing maintenance issues. It ensures that the water used within the towers remains clean and free of harmful contaminants.

Regularly maintained filtration systems result in long-lasting equipment. This ensures users, like data centers, run smoothly without frequent parts replacement, offering additional savings. Ultimately, investing in proper filtration leads to robust and reliable cooling tower operations which safeguard the data center infrastructure over time. Contaminants such as dirt, debris, biological growth, scaling (minerals & salts) can be effectively and efficiently removed through mechanical filtration means. Full flow and side stream filtration are the two common filtration methods to filter the water in recirculation systems. Full flow utilizes a filter installed downstream of the cooling tower on the discharge side of the pump. It is sized to accommodate the full flow volume of the recirculating water. These systems may recirculate thousands of gallons per minute requiring capital expense and a large physical footprint. Side or slip stream filtration, on the other hand, can be a cost-effective method to address these contaminants by continuously filtering a percentage of the flow instead of the entire flow volume, as little as 3%. Thus, the filtration system footprint, capital investment and operational cost are significantly reduced without adverse performance as compared to full flow systems. Additionally, side stream filters can be cleaned off line without interrupting or shutting down the entire system, minimizing downtime.

Typical Stages in a Data Center Cooling Water Filtration Train:

Stage	Technology	Function
Pre-Filtration	Sand/Multimedia Filters	Remove coarse solids >25 µm
Fine Filtration	Cartridge or Bag Filters	Capture fine particulates (0.5–10 µm)
Softening	Ion-Exchange Softeners	Preventing scale from hardness ions
Reverse Osmosis	RO Membranes (as needed)	Remove dissolved salts and organics
Disinfection	UV or Chemical Biocides	Eliminate bacteria and biofilm risk

Benefits & ROI of Proper Filtration

Payback periods for filtration investments typically range from 6 to 18 months due to energy and water savings and reduced maintenance costs.

Benefit	Impact
Increased Heat-Exchange Efficiency	Up to 15–20% energy savings on chillers/cooling towers
Reduced Maintenance Costs	Fewer chemical cleanings, longer equipment life
Minimized Downtime	Lower risk of unplanned shutdowns due to fouling
Water Savings	Higher cycles of concentration reduce makeup water by 30–50%
Sustainability & Compliance	Meets regulatory discharge limits and supports ESG goals

Filtration Trends

Filtration trends in data centers are evolving rapidly in response to higher cooling loads, sustainability pressures, and the growing adoption of liquid cooling systems. The focus is on efficiency, automation, sustainability, and integration—enabling facilities to keep pace with increasing compute density and environmental expectations.

1.) Shift Toward High-Efficiency, High-Flow Filtration Systems

- Growing adoption of high flow pleated cartridges and automated backwash systems to handle large cooling loops with minimal manual intervention.
- Focus on reducing maintenance frequency and lowering operating costs through longer filter life and fewer changeouts.

2.) Integration of Filtration with Water Reuse and Recovery

- Trend toward closed-loop systems and graywater reuse requires higher-grade filtration to remove organics, particulates, and microbes from recirculated water.
- Filtration is a key enabler of water reuse technologies like Zero Liquid Discharge (ZLD) and condensate recovery.

3.) Smart Monitoring & Automation

- Real-time sensor integration (pressure differential, turbidity, flow rate) with Building Management Systems (BMS) or SCADA.
- Automated alerts for filter fouling or performance degradation—allowing predictive maintenance instead of reactive.

4.) Greater Emphasis on Biological and Microbial Control

- As water temperatures rise in modern high-efficiency cooling systems, there is more focus on biofouling control.
- Trends include using UV sterilization, advanced oxidation processes (AOPs), and low-residue biocides, alongside mechanical filtration.

5.) Sustainability & ESG Alignment

- Data centers are tracking Water Usage Effectiveness (WUE) alongside Power Usage Effectiveness (PUE).
- Filtration systems that enable higher cycles of concentration in cooling towers directly reduce water waste.
- Preference for eco-friendly filtration materials and non-disposable filter options where feasible.

6.) Support for Liquid Cooling Adoption

- With the rise of direct-to-chip and immersion cooling, filtration must evolve.
- Ultra-pure filtration for closed-loop liquid systems (e.g., <1 µm filters, deionization)
- Non-shedding materials to avoid contamination of sensitive cooling loops.

7.) Modular & Scalable Filtration Designs

- Trend toward prefabricated skid-mounted filtration units for faster deployment and easier scalability in edge and hyperscale data centers.
- Allows for phased expansion as data center loads grow without disrupting operations.

Effective Filtration - High Flow Filters

Using High Flow filters in a data center's cooling water system offers several key operational and cost-saving advantages compared to standard filtration setups. These filters are designed to handle large volumes of water at higher flow rates with fewer elements, making them ideal for large-scale, mission-critical environments like data centers.

1.) Greater Filtration Capacity

- High flow filters can process hundreds of gallons per minute (GPM) per element.
- Suitable for centralized filtration of cooling tower makeup, condenser water loops, or chilled water return.

2.) Smaller Footprint

- Fewer filter elements are required to achieve the same filtration rate.
- Reduces the size of housings and overall system footprint—valuable in space-constrained facilities.

3.) Reduced Maintenance & Downtime

- Longer service life between cartridge changes due to higher dirt-holding capacity.
- Fewer cartridges mean faster changeouts and less labor, minimizing system interruptions.

4.) Lower Total Cost of Ownership

- Reduced labor, fewer consumables, and less disposal waste.
- Higher efficiency leads to fewer unplanned shutdowns and less equipment degradation over time.

5.) Improved System Efficiency

- Keeps cooling water **cleaner for longer**, reducing fouling on heat exchangers and cooling coils.
- Helps maintain o**ptimal heat transfer rates**, reducing energy consumption.

6.) Scalable for Growth

- Ideal for data centers with variable loads or rapid capacity expansion.
- Modular filter systems can be added or adjusted as the facility scales.

Conclusion:

Water filtration is a critical enabler of efficient, sustainable, and resilient cooling operations in data centers. Investing in proper filtration protects infrastructure, reduces environmental impact, and ensures uptime in mission-critical environments.