Water Treatment Projects at a DOE National Laboratory Improve High-Performance Computer and Utility System Performance and Environmental Impact

1. Introduction

National laboratories managed by the Department of Energy (DOE) often have extensive direct-to-chip liquid cooling, high-performance computing (HPC), and boiler systems that need to operate at peak efficiency to meet critical research goals. These facilities require a variety of customized water treatment solutions to maintain operating efficiency and preserve their assets.

One national laboratory was struggling with performance issues in process heating and cooling applications and needed assistance with environmental projects to improve wastewater discharge and water conservation. As a preferred water treatment consultant to the DOE, ChemTreat employed state-of-the-art technologies and provided technical and analytical support to address the lab's needs.

Systems addressed include:

- Open recirculating cooling tower systems
- HPC direct-to-chip liquid cooling loops
- Closed loop cooling systems
- Steam and condensate systems

Environmental projects include:

- Phosphate reduction in wastewater discharge
- Water conservation in cooling systems

2. Improving Cooling System Performance

2.1 Addressing Inefficiencies in Open Recirculating Cooling Towers

2.1.1 Project Description

The laboratory operates several large open recirculating water systems responsible for cooling critical research equipment and data center HPCs. These systems were fouled with mineral deposits that significantly impacted heat transfer and cooling efficiencies and contributed to increased metal corrosion and microbiological activity.

2.1.2 Solution

To address these issues, ChemTreat's Research & Development team developed a treatment solution using Quadrasperse® polymeric dispersant and corrosion inhibition technologies, specifically designed to meet the unique needs of this facility.

2.1.3 Results

After applying our custom-designed treatment program, mineral deposits were removed from the cooling tower fill and heat exchanger surfaces, significantly improving heat transfer efficiency and reducing the risk of underdeposit corrosion and microbiological activity.

For more than 10 years, the systems have remained free of mineral deposits and have exhibited excellent corrosion and microbiological activity control.

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2.2 Enhancing HPC Cooling Performance

2.2.1 Project Description

The facility has many computer applications with direct-to-chip liquid cooling, including a large, recently built unit that was unable to pass speed testing because of poor cooling performance.

The HPC's cooling loops had become heavily fouled with biological growth, mineral scale, and other additives, preventing the HPC from reaching the maximum expected calculations per second that it was designed to achieve.

Traditional cooling treatment methods add film inhibitors, such as silicates, to control corrosion, and biocides to mitigate microbiological issues. However, direct-to-chip liquid cooling systems have slightly different needs.

2.2.2 Solution

ChemTreat developed CL2001, a product specifically designed for CPU applications, to treat the laboratory's HPC cooling loops. This treatment methodology takes a more holistic approach, avoiding inhibitors that can cause fouling while implementing a proprietary protocol to control corrosion and microbiological activity.

2.2.3 Results

The CPU cooling at the site has been optimized with CL2001 treatment, and the HPC has passed the speed test. Stress testing is ongoing, and the laboratory is expected to accept ownership of the HPC from the manufacturer in the coming months.

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2.3 Addressing Fouling and Corrosion in Aluminum Closed Loop Cooling Systems

2.3.1 Project Description

The closed loop system was experiencing fouling events that led to underdeposit corrosion in aluminum equipment, reducing heat transfer efficiency.

2.3.2 Solution

The facility began using ChemTreat's patented FlexPro® multi-metal corrosion inhibitor specifically designed for aluminum applications. The new inhibitor has a neutral pH, allowing the cooling systems to operate within an acceptable pH range.

2.3.3 Results

Thanks to the application of the patented FlexPro corrosion inhibitor, the chilled water loop is now free from suspended solids caused by corrosion byproducts. The water clarity is excellent, and heat transfer and cooling efficiency have improved greatly.

Aluminum corrosion has been reduced from >10 mpy to <0.1 mpy.

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2.4 Improving Steam System Performance

2.4.1 Project Description

Steam is used throughout the facility for heating various applications. Research experiments utilizing live steam injection had previously prohibited the use of chemical treatment additives in the steam and condensate systems.

The untreated systems were experiencing component and piping failures as a result of severe corrosion. Costly ion exchange and filtration systems were required to prevent condensate corrosion products from depositing on boiler heat transfer surfaces.

2.4.2 Solution

With the elimination of concerns regarding the presence of chemical additives in the steam and condensate systems, ChemTreat initiated a treatment program to minimize equipment and piping corrosion and reduce the risk of corrosion product deposition in the boiler systems.

2.4.3 Results

With improved corrosion protection, the condensate iron concentration was reduced to <5 ppb, eliminating the need for operating costly ion exchange and filtration systems. Maintenance costs associated with equipment and piping replacement have been significantly reduced.

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3. Value-Added Sustainability Projects

In addition to treating the issues experienced by the laboratory's various water systems, ChemTreat implemented several programs to help the facility meet environmental goals.

3.1 Reducing Phosphate in Wastewater Discharge

At the request of the laboratory's environmental compliance team, ChemTreat specifically formulated an advanced cooling water corrosion and deposition control product free of phosphate and approved for discharge to natural streams.

3.2 Water Conservation Project

Utilizing a proprietary, state-of-the-art aluminum corrosion inhibitor, ChemTreat assisted the laboratory with a once-through to closed loop cooling water conservation project, saving 34 million gallons of water per year while protecting critical research equipment.

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4. Conclusion

ChemTreat's water treatment expertise and custom solutions helped a national laboratory improve the efficiency of its water systems and achieve its environmental goals.

The results of this partnership have yielded the following benefits for the facility:

- **Cooling tower systems have remained free of mineral deposits and have exhibited excellent corrosion and microbiological control for more than a decade**
- **Improvements to CPU cooling treatment helped the facility's HPC pass the speed test**
- **Aluminum corrosion reduction in the closed loop improved water quality and heat transfer efficiency**
- **Reduced iron concentrations in the condensate system resulted in lower operating costs associated with ion exchange and filtration processes as well as equipment replacement**

About ChemTreat, Preferred Supplier to DOE

Headquartered in Richmond, Virginia, ChemTreat is one of the largest and fastest-growing industrial water treatment companies in the world. We create lasting partnerships and sustainable value by aligning our entire organization around the common goal of making our customers more successful.

ChemTreat is honored to be a preferred supplier with a Basic Ordering Agreement for the DOE and its Integrated Contractor Purchasing Team. We deliver best-in-class water treatment solutions to DOE sites across the U.S.

5640 Cox Road / Glen Allen, VA 23060 / www.chemtreat.com