

White Paper:

Challenges of Commercial Cleaning in Dielectric Cooling Data Centers

Executive Summary

The rapid growth of Data Centers, driven by the increasing demand for high-performance computing (HPC) and artificial intelligence (AI) workloads, has led to the adoption of advanced cooling technologies such as Dielectric Cooling. Dielectric Cooling, including immersion and direct-to-chip cooling, uses non-conductive fluids to manage heat in Data Centers, offering superior efficiency compared to traditional air-cooling systems. However, these systems introduce unique challenges for commercial cleaning operations, which must adapt to maintain hygiene, comply with regulations, and ensure operational uptime. This White Paper explores the key challenges of commercial cleaning in Dielectric Cooling Data Centers, including fluid handling, contamination risks, regulatory compliance, and workforce training, while providing actionable recommendations to address these issues.

Introduction

Data centers are critical infrastructure for modern digital economies, powering cloud computing, AI, and big data analytics. As power densities increase, particularly with AI servers generating significant heat, traditional air-cooling methods are becoming inadequate. Dielectric Cooling, which involves submerging IT components in non-conductive liquids or circulating dielectric fluids through cold plates, has emerged as a sustainable and efficient solution. Industry insights indicate that 20% of data centers have adopted liquid cooling systems, with immersion cooling gaining traction for high-density environments.

While Dielectric Cooling enhances thermal management and reduces energy consumption, it poses unique challenges for commercial cleaning operations. Cleaning in these environments requires specialized protocols to prevent contamination, ensure equipment safety, and comply with health, safety, and environmental regulations. This White Paper examines these challenges and offers strategies to overcome them, ensuring Data Centers maintain optimal performance and hygiene.

Key Challenges of Commercial Cleaning in Dielectric Cooling Facilities

1. Dielectric fluids, such as synthetic oils or fluorocarbons, are non-conductive and designed to absorb heat from IT components without damaging electronics. However, their use introduces cleaning challenges:

- ✓ **Contamination Risk:** Dust, debris, or improper cleaning agents can contaminate dielectric fluids, reducing their thermal efficiency and potentially damaging components. For example, cleaning fluids that are not compatible with dielectric liquids can cause chemical reactions or residue buildup, leading to equipment failure.
- ✓ **Fluid Maintenance:** Dielectric fluids in immersion cooling systems can accumulate contaminants over time, requiring regular filtration or replacement. Cleaning Teams must coordinate with facility managers to handle fluid changes without disrupting operations.
- ✓ **Leakage Risks:** Direct-to-chip cooling systems, which circulate dielectric fluids through cold plates, are susceptible to leaks. A single leak during cleaning operations can damage electronics, cause downtime, and pose environmental risks if fluids are not properly contained.

Recommendation: Implement strict cleaning protocols that include the use of Dielectric-Compatible cleaning agents and tools. Train cleaning staff on proper fluid handling and disposal procedures, adhering to manufacturer guidelines for dielectric fluids. Use advanced filtration systems to maintain fluid purity and schedule cleaning during planned maintenance windows to minimize disruption.

2. Commercial cleaning in Dielectric Cooling Data Centers must comply with stringent health and safety regulations, such as those from the Occupational Safety and Health Administration (OSHA) and Leadership in Energy and Environmental Design (LEED) standards. Key challenges include:

- ✓ **Exposure to Dielectric Fluids:** While most Dielectric Fluids are non-toxic, prolonged exposure or improper handling can pose health risks to cleaning staff. Some fluids may require specific personal protective equipment (PPE) to prevent skin or respiratory irritation.
- ✓ **Indoor Air Quality (IAQ):** The Environmental Protection Agency (EPA) estimates that poor IAQ causes 150 million lost workdays annually. In Dielectric Cooling

environments, cleaning processes must avoid introducing volatile organic compounds (VOCs) or other airborne contaminants that could degrade IAQ.

- ✓ Regulatory Standards: Cleaning companies, Like Checkmark, must ensure compliance with OSHA regulations for chemical handling and LEED criteria for environmentally preferable products. This requires specialized cleaning solutions that do not leave chemical residues or impact the Dielectric Fluid's properties.

Recommendation: Use greener, environmentally preferable cleaning products certified for low VOC emissions to maintain IAQ. Provide comprehensive PPE Training and ensure cleaning staff are certified in OSHA-compliant chemical handling. Conduct regular IAQ assessments to monitor and mitigate risks.

3. Dielectric Cooling Systems, particularly immersion cooling setups, require unique infrastructure, such as tanks and pumps, which complicates cleaning processes:

- ✓ Access to Components: In Immersion Cooling, servers are submerged in tanks filled with Dielectric Fluid, making it difficult to clean surfaces without specialized tools or disrupting operations. Cleaning Teams must navigate tight spaces and avoid disturbing sensitive equipment.
- ✓ Equipment Compatibility: Traditional cleaning tools, such as vacuums or chemical sprays, may not be suitable for Dielectric Cooling Environments. For example, water-based cleaning solutions can contaminate Dielectric Fluids, while abrasive tools can damage tank surfaces or electronics.
- ✓ Space Constraints: Immersion Cooling Systems can reduce Data Center infrastructure size by one-third compared to air-cooled systems, but this compact design leaves less room for cleaning staff to maneuver.

Recommendation: Invest in specialized cleaning equipment, such as non-conductive brushes, dielectric-safe wipes, and low-pressure vacuums designed for Data Center environments. Develop cleaning procedures that account for compact layouts and ensure compatibility with Immersion Tank Materials. Collaborate with Data Center operators and General Contractors (GCs) to design accessible cleaning pathways.

4. The complexity of Dielectric Cooling Systems demands a highly skilled cleaning workforce, which is a growing challenge in the industry:

- ✓ Technical Knowledge: Cleaning staff must understand the intricacies of Dielectric Cooling Systems, including fluid properties, system components, and potential risks. This requires training beyond standard commercial cleaning practices.
- ✓ Shortage of Skilled Labor: Dodge Data and Analytics highlight a shortage of skilled workers in Data Center operations, including HVAC and cooling

- ✓ specialists. This shortage extends to cleaning professionals trained for Dielectric Cooling Environments.
- ✓ Adapting to Evolving Technology: As dielectric cooling technologies evolve (e.g., two-phase immersion cooling or nanofluid-based systems), cleaning protocols must keep pace with new requirements, increasing the need for continuous training.

Recommendation: Develop specialized training programs for cleaning staff, focusing on dielectric cooling system safety, fluid handling, and contamination prevention. Partner with data center operators or cooling technology providers to offer hands-on training. Leverage industry certifications, such as those from the International Sanitary Supply Association (ISSA), to ensure staff expertise.

5. Data centers require 24/7 Uptime, making it challenging to schedule cleaning maintenance without disrupting operations:

- ✓ Operational Constraints: Cleaning in Dielectric Cooling environments often requires shutting down or isolating equipment, which can conflict with Service Level Agreements (SLAs) demanding continuous availability.
- ✓ Coordination with IT Teams: Cleaning operations must be synchronized with IT maintenance schedules to avoid interference with cooling systems or fluid circulation processes.
- ✓ Cost of Downtime: Unplanned downtime due to cleaning errors, such as fluid contamination or leaks, can result in significant financial losses. Various Studies indicate a 61% increase in the cost of unplanned Data Center outages in the last six (6) years.

Recommendation: Schedule Maintenance Cleaning during low-demand periods or planned maintenance windows to minimize downtime. Use Predictive Maintenance tools, such as IoT-enabled sensors, to monitor fluid and equipment conditions, allowing cleaning to be timed with necessary fluid changes or system checks.

Strategies for Overcoming Challenges

To address the challenges of Commercial Cleaning in Dielectric Cooling Data Centers, the following strategies are recommended:

1. **Develop Specialized Cleaning Protocols:** Create detailed standard operating procedures (SOPs) for cleaning Dielectric Cooling Systems, including fluid handling, equipment compatibility, and contamination prevention.
2. **Invest in Advanced Cleaning Technologies:** Adopt tools like Dielectric-Safe vacuums, non-conductive brushes, and IoT-enabled cleaning systems to enhance efficiency and safety.
3. **Enhance Workforce Training:** Partner with industry organizations and cooling technology providers to offer regular training on Dielectric Cooling Systems and regulatory compliance.
4. **Collaborate with Data Center Operators:** Work closely with facility managers to align cleaning schedules with maintenance windows and leverage predictive maintenance tools for optimal timing.
5. **Prioritize Sustainability:** Use environmentally preferable cleaning products and implement waste management protocols to align with the sustainability goals of dielectric cooling data centers.
6. **Monitor and Adapt:** Continuously assess cleaning performance through IAQ testing, fluid purity checks, and feedback from data center operators to adapt protocols as technologies evolve.

Conclusion: Dielectric Cooling represents a transformative shift in Data Center Thermal Management, offering energy efficiency and support for high-density workloads. However, commercial cleaning in these environments presents significant challenges, from handling Dielectric Fluids to ensuring regulatory compliance and maintaining Uptime. Cleaning businesses, like Checkmark, that adapt to these unique demands will gain a competitive edge in the modern marketplace.