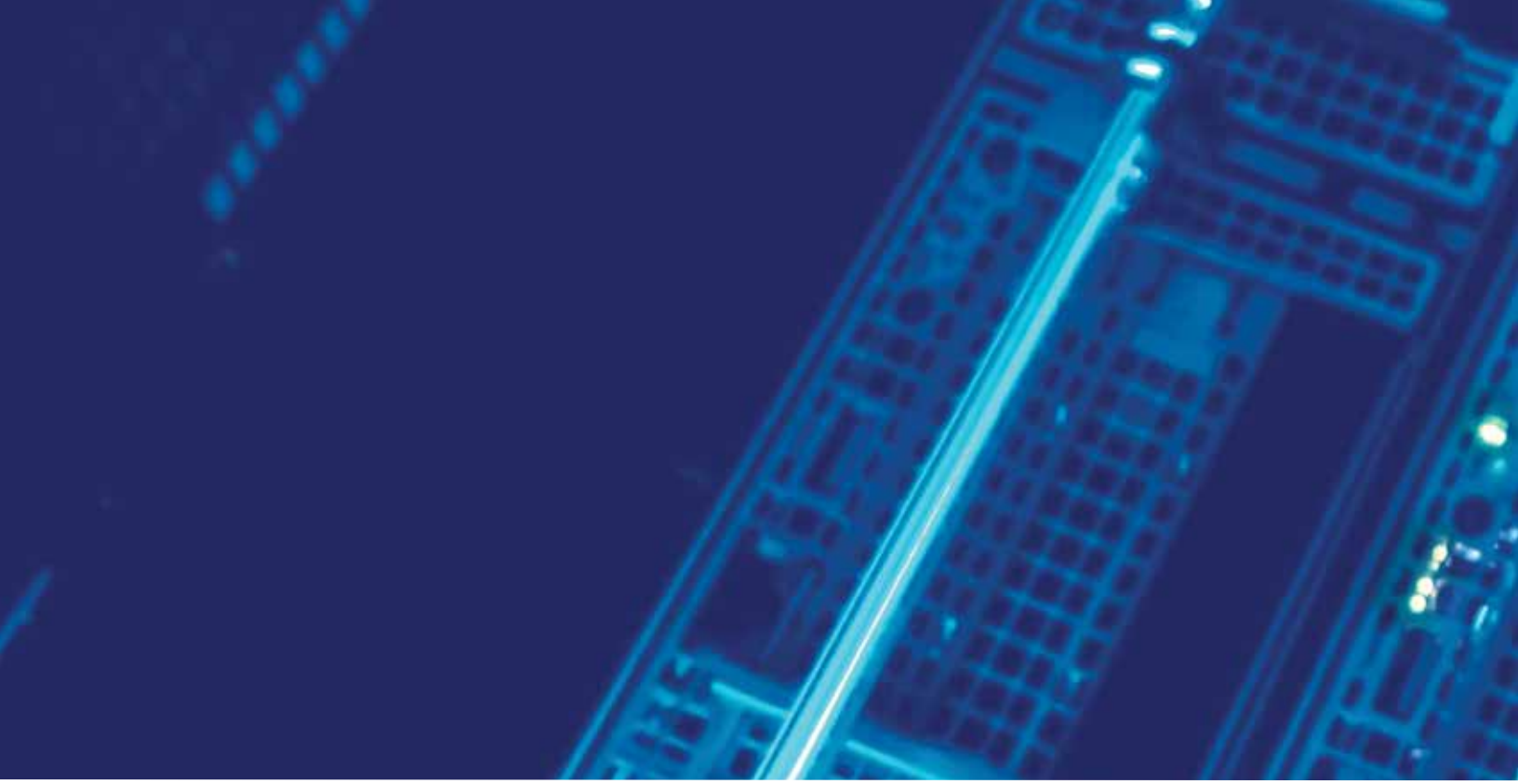
CompuZol™
IMMERSION FLUID SOLUTION
By Lubrizol

TURNING DOWN THE HEAT

Fluid Engineering that Enables Next-Generation Immersion Cooling

An overview of fluid engineering's role in the evolution of single-phase fluid immersion cooling.



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INTRODUCTION

The Information Age has fundamentally changed not only the way we use technology, but also how society adapts to the rapid evolution of technology. Access to and use of data is expanding and driving the needs of modern IT (Information Technology) infrastructure, including an ever-increasing number of data centers globally.

Notably, workloads in these facilities have increased exponentially. And as ever-more processing and storage capacity are needed to advance business and our experiences, the engineers who oversee data center infrastructure have the problematic task of supporting greater power density amidst physical space limitations.

One of the more considerable challenges? How to manage the heat generated through increased workloads and data processing capability, especially as energy management is a critical element of data center design and use.

Conventional air-cooling methods struggle to efficiently handle greater power densities and the resulting heat. Indirect (cold plate) cooling systems offer advantages, but they also cost more and rely on water, an increasingly limited resource.

Immersion cooling, a method in which IT hardware is submerged in fluid, is a maturing, practical option for overcoming heat issues, with incremental benefits when compared to legacy cooling systems.

Additionally, the fluid itself offers foundational advantages as it can be tailored to meet the requirements of current and future applications.

Read on to explore practical reasons for why data centers are adopting immersion cooling and gain a better understanding of how fluid engineering is enabling the next generation of immersion systems.

THERMAL MANAGEMENT AND DATA CENTERS

Cooling Options

Air-Cooling – The most conventional method for mitigating heat concerns, air-cooling systems have been around for decades. They work by releasing cool air into a space and making it available in the cool aisle, allowing the IT hardware to draw it, mostly, in the front of the hardware, and across the components, then ejecting it out the back into the hot aisle. That hot air is then returned, cooled, and delivered back into the data center, completing the cycle. While these systems were suitable when power usage needs were lower, they're becoming increasingly inadequate to manage the growing workloads and heat production of modern data center equipment. Simply put, the amount of heat coming from higher power systems is too great for air-cooling to be effective or efficient. Energy management can also be an issue, with some newer air-cooled data centers reporting Power Usage Effectiveness (P.U.E.) as high as the 1.3-1.5 range.

Indirect (Cold Plate) Cooling Systems – Cold plates offer a step up from conventional air-cooling. They work by absorbing and dissipating heat through closed-loop liquid-cooling systems. More efficient and compact than traditional air-cooling systems, they offer clear advantages. But there are also downsides. For one, they cost more. Many also rely on water. Depending on the local water supply, tubes and water pumps can corrode over time, increasing the risk of leaks in spaces filled with electronics.

Immersion Cooling – Immersion cooling is a developing technology gaining adoption as a practical option for overcoming data center heat issues and the subsequent loss of rack density. In this method of thermal cooling, all computer components are submerged in non-conducting fluids, offering a range of benefits compared to air-cooling and indirect cooling systems.

Heat has always been an enemy to data centers. System durability and useful life expectancy, performance capacity, and reliability are all factors that engineers must consider.

Multiple thermal management options exist to address growing power usage demands, but they're not all created equal.

Two fundamental types of immersion cooling systems are in use today, known as single-phase and two-phase. Though both methods involve fully submerging hardware in fluid, each approach is markedly different.

Single-Phase

In single-phase immersion cooling, hardware is submerged in a dielectric fluid that makes direct contact with the IT equipment, conducting heat away as the fluid flows through a heat rejection mechanism, such as a heat exchanger, which is typically operated with facility water. Organic or halogenated fluids may both be used in this application, although the latter are typically associated with higher cost and a less favorable environmental sustainability profile.

Two-Phase

In two-phase cooling, a fluorocarbon-based fluid readily boils when in contact with equipment hot spots, transitioning the fluid from a liquid to a vapor that can be condensed in a heat exchanger and recirculated into the cooling tank. This phase change of liquid to gas allows the fluid to draw large amounts of heat from the equipment, but also requires integration of system design elements to facilitate the transition and a sealed system to prevent costly fluid loss from evaporation.

Single-phase Potential

Both single-phase and two-phase systems offer superior efficiency, high-density performance, and cooling characteristics versus conventional systems. However, there is significant potential to tailor the fluid in a single-phase system, creating an opportunity for solutions that meet the needs of future hardware, without incurring the inherent environmental and cost issues of two-phase cooling.

Benefits of Single-phase Immersion Cooling

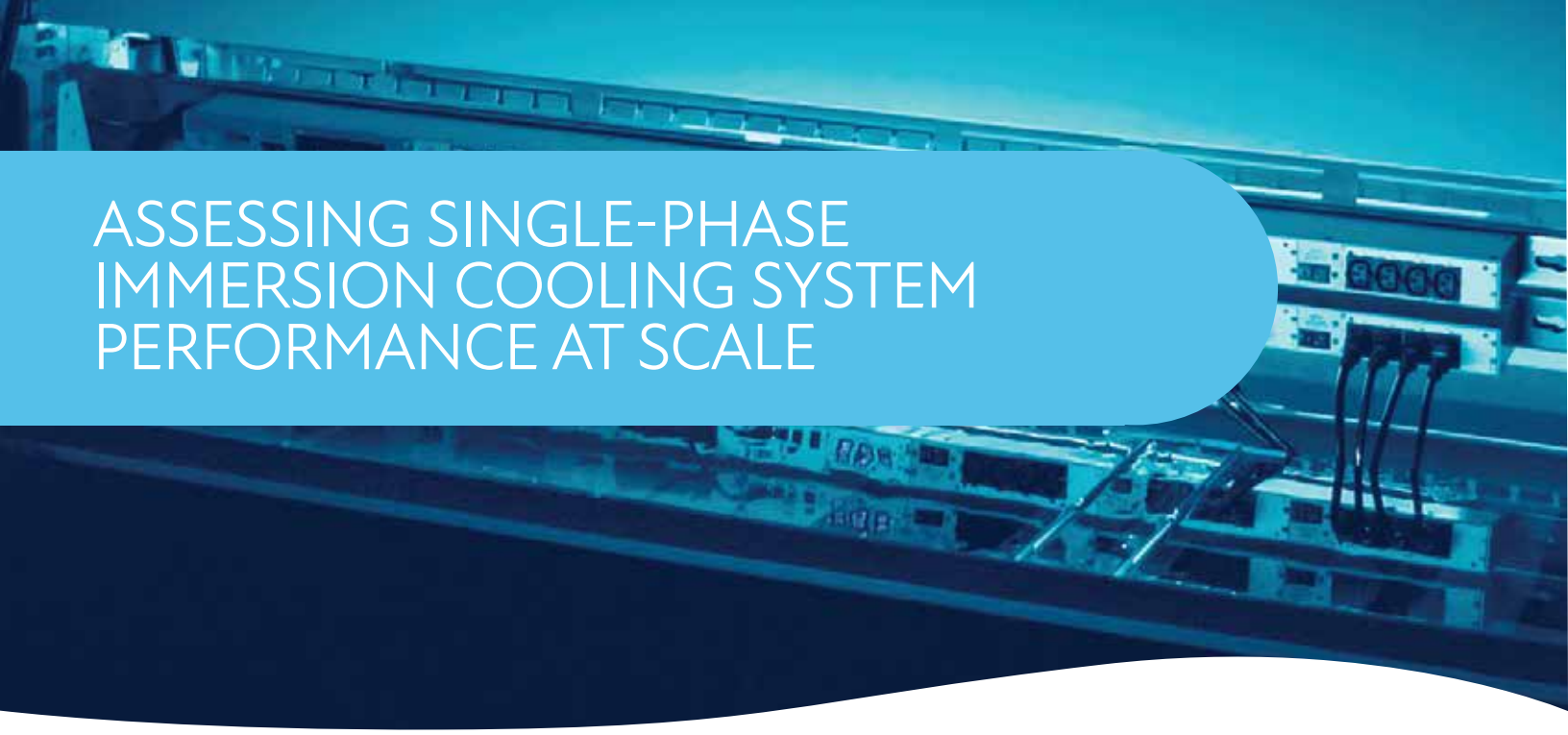
Power Density – Allows data centers to house and maintain server infrastructure to deliver more computing density and meet increased demand.

Thermal Performance – Less equipment throttling or downtime is experienced in systems with effective thermal management fluids. Single-phase immersion systems can also extend IT equipment lifetime compared to air- and indirect-cooling systems by reducing server design complexity (e.g., no integrated fans required) and reducing operating temperatures to prevent thermal degradation of server components.

Power Usage Effectiveness (P.U.E.) – Eliminates the need for power-hungry air-cooling systems, allowing facilities to divert more kilowatt consumption directly to hardware.

Sustainability – Uses less water than other cooling solutions/technologies and eliminates fluorocarbon-based fluids (commonly used in two-phase cooling) that may have unfavorable global warming potential or chemical reactivity profiles.

Support Diverse Environments – Free air-cooled data centers are limited to locations where the outside temperature is less than the data center setpoint. Further, the outside air must be clean of pollutants to avoid having to scrub the air. Immersion cooling allows data centers to be located anywhere geographically since it does not require external air to be brought into the data center for IT equipment cooling.



ASSESSING SINGLE-PHASE IMMERSION COOLING SYSTEM PERFORMANCE AT SCALE

Given the projected growth potential for IT infrastructure, the industry has naturally started investigating opportunities to enable single-phase immersion cooling for adoptability at scale. Some of the key scaling considerations in that conversation include the fluid itself, thermal performance, material compatibility, fluid durability, sustainability and energy management, regulatory compliance, safety, and cost.

"One-size-fits-all" Fluids

Early generation immersion cooling fluids were sourced from base stocks designed for different applications and industries and repurposed for use in data centers. While this approach enabled early access to immersion-capable fluids, these options are not sufficient to maximize equipment lifetime and performance or to meet the more demanding thermal requirements of next-generation equipment. Immersion fluids, developed and designed, offer balanced properties and better material compatibility to meet the unique needs of data center facilities and their equipment.

Sustainability and Energy Management

You may be surprised to learn that today's data centers emit as much carbon dioxide as the commercial airline industry. Single-phase immersion cooling solutions can reduce carbon emissions, positively affect energy consumption, and more. Taking it a step further, engineers are also intrigued by ideas of heat recapture and energy reuse, possibilities that could one day power data centers themselves or even nearby communities.

Fluid Durability

Though they experience some degree of degradation today, existing single-phase fluids are often considered "good enough." As power demands increase, engineers are interested in how the next generation of fluids can help extend the useful life expectancy of their hardware.

Safety and Cleanliness

As immersion cooling is adopted, facility managers are keenly aware that the introduction of fluid into a computer hardware environment presents operational considerations.

Fluid Engineering's Role in Next-generation Thermal Management

To help navigate these considerations, the world's leading fluid engineers have begun working side by side with the IT industry to enable next-generation fluids for immersion cooling in data centers.

Lubrizol®, a Berkshire Hathaway company with 30+ years of thermal management and formulating experience, is leading the charge in this category. With experience tailor-formulating solutions for both the automotive and data center marketplaces, including scalable x86 infrastructure, the organization offers a wealth of learnings from earlier work that it has used to future-proof, supply and maintain innovative solutions for the IT industry.

CompuZol™ Immersion Fluid Solution

As an example of the collaboration in action, Lubrizol® created its line of CompuZol™ immersion cooling fluids with input from industry-leading partner, Intel®.

Not only do CompuZol™ fluids offer best-in-class material compatibility, durability, and dependable thermal performance to enable increased computing density, but they also address growth barriers posed by conventional cooling methods. Specifically, these next-generation fluids can help data centers:

- Reduce cooling costs by 30+ percent
- Achieve better P.U.E.
- Maximize mean time between failures (MTBF)
- Extend the serviceable life of hardware

Beyond the Technology

There are also added benefits beyond chemistry. Drawing on its longstanding role as a global fluid leader, Lubrizol is not only uniquely positioned to develop next-generation immersion fluids but can also inform stakeholders of best practices for fluid management up and down the value chain.

The topic of fluid management is a prime example as data centers will need reliable processes for drain interval and disposal oversight – two areas where Lubrizol can advise.

Next-Generation Thinking

Another benefit of working with a fluid engineering company is the ability to innovate and evolve technology beyond what we believe is possible today.

Energy recapture and reuse, for example, could one day revolutionize the way data centers are powered. By drawing on Lubrizol expertise, that could happen sooner rather than later.

Conclusion

Today's data center operators need to do more with less – less energy, physical space, downtime, and consideration of the environmental impact. Single-phase immersion cooling presents the market with a practical long-term solution to overcome the heat issues that plague modern-day data centers. It also offers a range of benefits that address energy efficiency, environmental challenges and more.

Working hand in hand with market leaders, like Intel, Lubrizol and our team of fluid engineers will play a critical role in the continued evolution of immersion cooling technology, helping the data center hardware industry achieve scalable solutions for data centers in the coming years.

Better performance. Bigger profits.

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