Case study

Data Center Optimization
Immersion Cooling

Trusted Liquid Cooling for Modern Data Centers

Comprehensive testing of Shell Immersion Cooling Fluids delivers the first-ever Intel® Data Center Certified for Immersion Cooling solution, unlocking opportunities for reduced data center cooling costs and more sustainable computing while increasing rack density.

At a glance:

- As data centers strive to meet increasing AI and high-performance computing demands, cooling efficiency and sustainable computing practices become more important than ever.
- In collaboration with Shell Global Solutions (US) Inc., Intel has validated the industry's first Intel® Data Center Certified immersion cooling system—featuring Supermicro Big Twin servers powered by Intel® Xeon® processors immersed in Shell Immersion Cooling Fluids (ICFs) within a Submer SmartPod, boosting customer confidence in data center hardware compatibility for deployments at scale.
- The system supports data centers' high-performance and sustainability goals—CPU performance matches the performance in an air-cooled environment; the Shell ICFs are PFAS-free; and data centers may be able to cut energy use by up to 48%, as well as reduce capital and operating expenditures.[1]
- Intel is the only semiconductor manufacturer that certifies its products for deployment in an immersion cooling solution, backed by a warranty. With this certification, Intel offers a Xeon Processor Single-Phase Immersion Warranty Rider that affirms confidence in the durability, efficiency, and compatibility of immersion-cooled IT infrastructure with Shell ICFs.

Challenge

If you are responsible for the day-to-day operations of a data center, you know the drill: C-suite executives' mantra to cut costs and carbon footprint is pitted against end users' continual demand for more compute capacity. Much of this demand is driven by AI. Analyses indicate that demand for AI-ready data center capacity will rise at an average rate of 33% per year between 2023 and 2030, ultimately accounting for roughly 70% of all data center capacity by 2030.[2]

Shell is no stranger to the seemingly conflicting demand for cost efficiencies and sustainability versus more data center megawatts. Its extensive research and development (R&D) efforts are increasingly powered by compute-hungry AI-driven modeling and simulation and computer vision applications.

However, as server rack densities and compute capacity grow, traditional air-cooled data centers become markedly less energy efficient. Recent studies show that cooling can account for up to 40% of total energy use in standard air-cooled facilities.[3] Recognizing its own—and the world's—need for innovative data center cooling solutions, Shell is developing environmentally friendly fluids for immersion cooling of data center infrastructure. However, immersion fluid is only one aspect of implementing an immersion cooling solution. Compatible servers, microprocessors, and immersion tanks are also necessary to help ensure the reliability of the immersion cooling solution through its intended service lifetime.

Shell turned to its long-time innovation collaborator, Intel, along with server OEM Supermicro and immersion tank experts at Submer to validate an immersion cooling solution that data center customers could deploy quickly and confidently.

An Intro to Single-Phase Immersion Cooling

Immersion cooling submerges computer components or entire servers in a thermally conductive, dielectric liquid. Single-phase fluid remains in a liquid state throughout operation; it doesn't boil or freeze. The specialized fluid is pumped through a heat exchanger, where the heat is then transferred to a cooler water circuit. Single-phase immersion cooling eliminates the need for onboard server fans, computer room air conditioning (CRAC) units, and complex air-side infrastructure. Because the fluid has a thermal conductivity that is about 5x that of room-temperature air, it can extract heat more rapidly, enabling data centers to handle higher power densities per rack compared to air-cooled setups. Using immersion cooling, data centers may be able to improve power usage effectiveness (PUE) and reduce energy consumption and maintenance costs. Also, servers may experience fewer thermal hotspots, improving hardware longevity and uptime.

Solution

Working together for two years, the team consisting of Intel, Shell, Supermicro, and Submer developed and validated a full immersion solution for data centers. The resulting system—Intel Data Center Certified for Immersion Cooling—sets a new industry standard[5] for cooling efficiency and long-term performance with the first immersion solution for 4th Gen and 5th Gen Intel® Xeon® processors. Intel complements this certification with a Xeon Processor Single-Phase Immersion Warranty Rider, which guarantees hardware durability when deployed with Shell's immersion fluids, based on the lab's reliability data.

The certified system includes several components:

- Shell's single-phase immersion cooling fluids (ICFs), which are colorless and odorless hydrocarbon-based dielectric fluids. Shell ICFs have been extensively tested for material compatibility for the bill of materials used in the Big Twin servers and found to be highly compatible with the various hardware components tested. Shell single-phase ICFs are free of per- and polyfluoroalkyl substances (PFAS), making them non-toxic, eco-friendly, and biodegradable to varying degrees.
- Supermicro Big Twin servers that include specific modifications. Examples include modifications to the power supply to improve material compatibility, modifying the fin pitch of the heat sinks for optimized performance in single-phase hydrocarbon fluid viscosities, and choosing thermal interface materials that will not dissolve and contaminate the immersion fluid. These multi-node, highly dense servers are ideal for high-performance computing environments.
- 5th Generation Intel Xeon processors, which are purpose-built for AI. These processors can help boost performance, reduce costs, and improve power efficiency for today's demanding workloads.
- Submer's SmartPod EVO line of immersion tanks, which range from 26U to 56U in size. These tanks offer compact design, fast deployment capabilities, and easy daily IT operations. They can also be deployed in hybrid environments, combining immersion cooling with air-cooled racks.

> *"Intel's processors are the best in the business—the best performance and best reliability. And Supermicro's servers are always extremely reliable, and now they're immersion-ready. So, for this project, we were lucky enough to be able to use hardware that delivers the best performance and reliability, and immersion readiness."*
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> **– Mark Miyoshi, Director of R&D, Submer**

Intel's Advanced Data Center Development Laboratory worked closely with Supermicro to integrate Intel Xeon processor-based server boards into submersion tanks and validate that board-level designs (such as power delivery networks and thermal interfaces) maintained signal integrity and electrical reliability under immersion. During early testing phases, which included comprehensive material compatibility testing using Open Compute Project testing guidelines, Intel and Supermicro worked together to resolve certain material incompatibilities. The lab staff also developed and optimized groundbreaking new tools that accurately measure factors like dielectric stability, corrosion effects over time, and thermal conductivity under peak load.

> *"Certification and validation are at the core of this collaboration, ensuring that data center operators have access to proven high-performance solutions they can trust. Combining deep technical expertise with a shared ambition from all of our partners has helped us to achieve this remarkable milestone."*
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> **– Dr. Selda Gunsel, Chief Technology Officer and Executive Vice President of Technology, Shell**

With this Intel-certified immersion cooling system, data center operators can skip lengthy proof-of-concept phases and proceed directly to large-scale deployment, backed by Intel's lab-verified performance and reliability testing.

Another benefit of the certified solution is that it allows Intel Xeon processors to run at their highest thermal design power (TDP) without worrying about throttling or jitter.

Meet the Team

Intel's Advanced Data Center Development Laboratory is a specialized R&D facility that is focused on rigorous testing and validation of next-generation data center technologies. By providing hardware-level certification, the laboratory gives data center operators confidence to deploy validated, high-performance infrastructure without lengthy proof-of-concept cycles. The site houses advanced test racks, instrumented immersion tanks, environmental chambers, and high precision power analyzers that enable comprehensive evaluation of server designs under varied operating conditions.

Shell's strategy focuses on delivering more value with less emissions, in support of its target to become a net-zero emissions energy business by 2050. Immersion cooling technology aligns with this strategy by enhancing energy efficiency and sustainability in data centers, supporting Shell's broader goals of reducing emissions from its own operations and helping its customers to transition to cleaner energy solutions.

Founded in 2015, **Submer** offers comprehensive, scalable, and sustainable immersion cooling systems. Its modular designs offer rapid deployment and adaptability, enabling efficient cooling in various environments, including edge and remote locations. Submer operates globally with a headquarters in Barcelona and a gigafactory in Houston, Texas, serving hyperscalers, colocation providers, and large enterprises.

Supermicro is a leading U.S. technology company headquartered in San Jose, California. It specializes in high-performance, energy-efficient server and storage solutions for markets including enterprise data centers, cloud computing, AI, 5G, and edge computing. The company's product portfolio encompasses rack-scale servers, GPU-optimized systems, network switches, and management software, all designed under its "Building Block Solutions" philosophy to maximize flexibility and efficiency.

According to Mark Miyoshi, Director of R&D at Submer, Intel Xeon processors in the immersion cooling environment with Shell's dielectric fluid can maintain optimal performance with no performance degradation due to interactions between the processor and Shell ICFs.

Results[6]

The Intel Data Center Certified for Immersion Cooling proves that Intel Xeon processors remain as reliable in Shell's ICF as in traditional air-cooled systems, with the following additional benefits:

- Shell ICFs have the capability to enhance performance with up to 40% greater CPU performance and 48% less electricity consumption.
- The use of Shell's ICFs promotes environmental sustainability with roughly 99% less water consumption, up to 30% fewer CO2 emissions, and up to 99% energy ready for re-use as 55°C hot water.
- Where deployed, Shell ICFs provide high reliability and are not constrained by climatic conditions—that is, Shell's ICFs work effectively in hot and humid environments.
- Shell's ICFs help to optimize data center operations where deployed, requiring up to 80% less floor space.

Data center administrators seeking alternatives to traditional air cooling can have confidence when deploying the Intel Data Center Certified immersion cooling system. The system is backed by extensive testing and a warranty, and is highly scalable and flexible. From just a few racks to an entire data center, the system can grow to meet a variety of needs. It can also be used in hybrid data center cooling environments.

A Closer Look at Shell's Immersion Cooling Fluids

In 2018, Shell launched its first immersion cooling fluid (ICF) for data centers. The Shell ICF portfolio is designed on a linear high proportion of iso-paraffins and low content aromatic and ring components. Shell ICFs exhibit improved high thermal and oxidation stability. Shell ICFs are bright, clear, and translucent.

Shell ICFs are produced using Gas-to-Liquid (GTL) technology, which is an umbrella term describing the process of producing synthetic hydrocarbon liquids through the three-phase Fischer-Tropsch process.

In the first stage, synthesis gas, a mixture of dihydrogen and carbon monoxide is manufactured from natural gas by partial oxidation. Impurities are removed from the synthetic gas. The second stage uses a catalyst to convert the synthetic gas into liquid hydrocarbons. The final stage is cracking and isomerization, which cuts the molecule chains into shorter lengths. This yields high-quality liquids such as diesel, kerosene, lubricant oils, and ICFs. Shell S3 X and S5 LV are Shell's high-performance ICFs designed for data centers using next-generation processors with high thermal design power (TDP) characteristics.

Solution Ingredients

- Intel® Xeon® processors
- Supermicro Big Twin servers
- Shell Immersion Cooling Fluids
- Submer SmartPod EVO tank

Learn more by visiting the **Intel® Data Center Certified Validation** web site.

intel. x

[1] Source: https://www.shell.com/business-customers/lubricants-for-business/news-and-media-releases/2025/shell-cooling-fluids-certified-by-intel-for-use-in-data-centres-worldwide-an-industry-first.html.
Global immersion cooling market in data centers–growth, trends and forecast (2019-2024) report (Mordor Intelligence) and Shell's internal evaluations. Benefits achieved will vary according to actual site development.

[2] McKinsey, October 2024, "AI power: Expanding data center capacity to meet growing demand."

[3] McKinsey, January 2023, "Investing in the rising data center economy."

[4] Source for S5 LV fluid thermal conductivity: https://industrialfluidsmfg.twinoils.com/item/specialty-lubricants/alty-lubricants-dielectric-immersion-cooling-fluid/550056018.
Source for room temperature air thermal conductivity: https://matmake.com/properties/thermal-conductivity-of-air.html.

[5] Compared to traditional air cooling, single-phase immersion cooling can help to reduce electricity demand by up to nearly half, contribute to CO2 emissions reductions of up to 30%, and support up to 99% less water consumption. When integrated with renewable power and smart energy management solutions, the deployment of single-phase immersion cooling can support data centre operators' goals of optimising performance sustainably. Figures based on: Global immersion cooling market in data centres - growth, trends and forecast (2019-2024) report (Mordor Intelligence) and Shell's internal evaluations. Benefits achieved will vary according to actual site development.

[6] These figures are based on the Global immersion cooling market in data centers - Growth, trends, forecast (2019 -2024) report, Mordor Intelligence; Asperitas' test results; and Shell's internal evaluation. The benefits achieved will vary according to the actual site deployment..

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