SEALS FOR DATA CENTERS

Increased thermal management requires increased needs for sealing solutions.

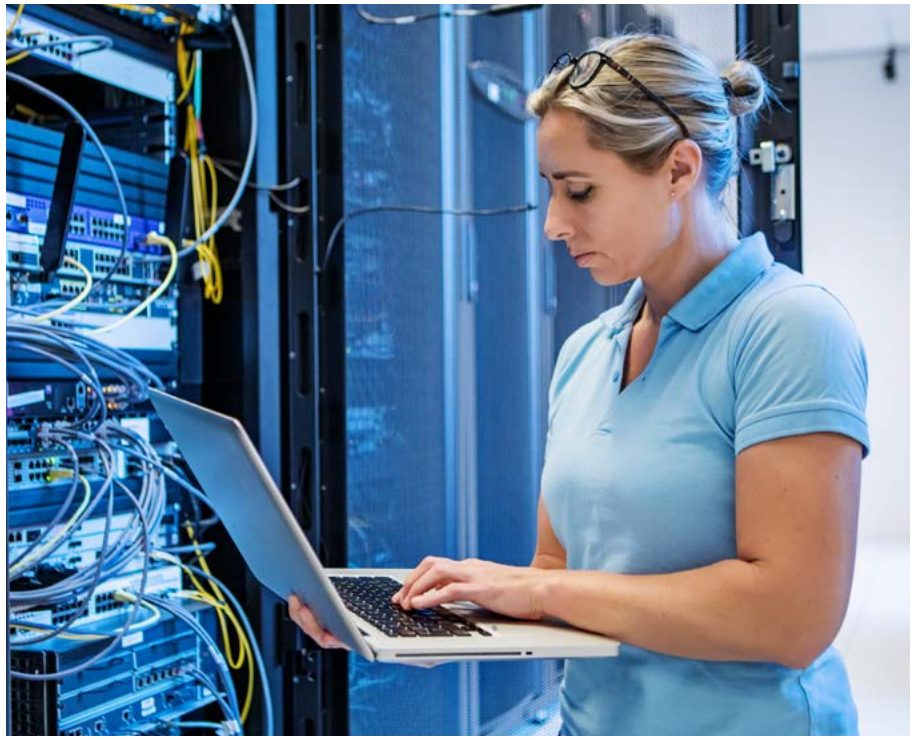
Parker

SEALING SOLUTIONS FOR THERMAL MANAGEMENT INNOVATION IN DATA CENTERS

The Rising Need for Thermal Management in Data Centers

The need for enhanced thermal management is not expected to decline or even plateau. Highly demanding industries, the blistering pace of technology advancements, and the increasing use of multi-core chips are forcing data centers to deal with hotter temperatures. What's more, airflow through data centers is increasingly hindered as dense new arrays of equipment are added.

Gone are the days when data centers could just turn up the air conditioning and add more fans. Those steps cannot keep up with the heat generated by the increasing number of chips operating at soaring levels of storage and processing.



Data Centers Choosing Liquid Cooling

For these reasons, an increasing number of data center managers are looking toward liquid cooling. Formerly considered a risky choice by those who feared the prospects of liquid contacting electronics, liquid cooling is fast gaining converts among those whose responsibilities include efficient, effective thermal management.

Direct CPU Cooling represents a majority of the market and relies on cold plates mounted directly to the heat-generating chips that route a water-based coolant for thermal transfer.

Liquid Immersion represents a smaller share of the market and can be separated out further into single phase or 2-phase. Single-phase Liquid Immersion Cooling typically involves synthetic hydrocarbon dielectric fluids with the entire server immersed in coolant. Two-phase cooling involves spraying an evaporating coolant directly onto the circuit, then collecting and condensing the coolant for re-use.

The fact liquid cooling is no longer viewed as off-limits in data centers can be attributed to the high level of design, engineering, and manufacturing control directed to the necessary hardware reflected in the increasing design of modular CPU's and GPU's. Modularity allows for upgrades and replacements without the need for specialized tools or processes like welding, but with modularity comes an increased need for reliable sealing solutions for increasingly complex and custom design requirements concerning o-rings, gaskets, and diaphragms.

Reliability, of course, cannot be taken for granted. Datacenter managers should consult with their designers and engineers involved in the manufacturing of liquid cooling systems to learn the performance attributes and test results of critical parts and assemblies. As more information becomes available about liquid cooling systems' benefits and performance, especially in the area of mitigating risks associated with leaking liquids, smart decisions are easier to make.

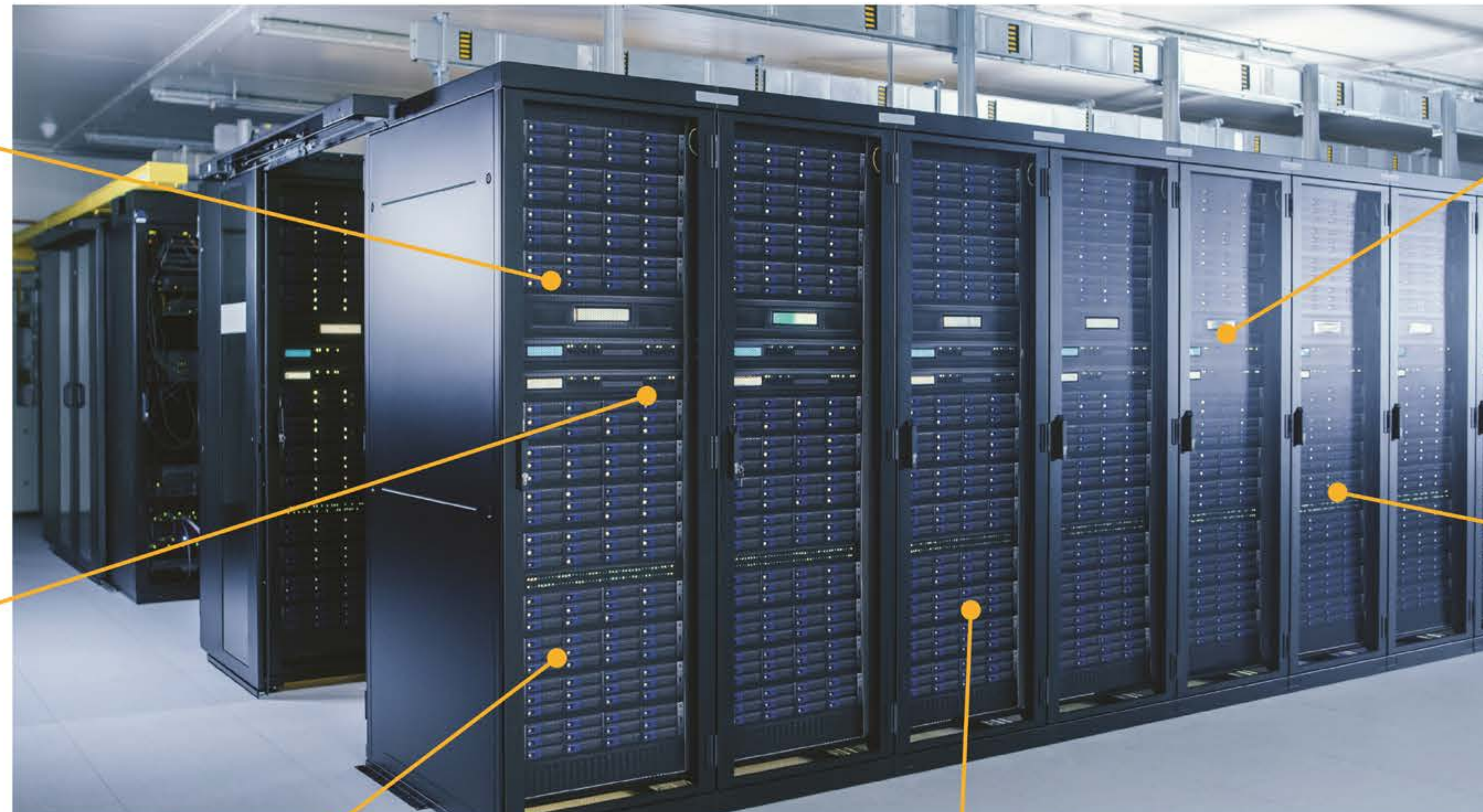
Sealing Solutions for Data Centers:

In liquid cooling systems for data centers, various types of seals are used to ensure leak-free operation and maintain the integrity of the cooling system. Here are some common types:

1. **Custom Rubber Seals:** These seals are uniquely designed to compress between two surfaces to create a tight seal. They are primarily used in applications where off-the-shelf seals are not a good fit or where multiple seals can be combined into a single design.
   - **O-Rings:** These are widely used due to their simplicity and effectiveness in creating a tight seal. They are typically made from elastomers like silicone, EPDM, or fluorocarbon, which can withstand different temperatures and chemical exposures.
   - **Gaskets:** These are flat seals placed between two surfaces to prevent leakage. They can be made from materials such as rubber, silicone, or PTFE, and are often used in flanged connections.
2. **Dripless Connectors:** These are specialized connectors designed to prevent fluid loss during connection and disconnection. They are particularly useful in modular systems where components may need to be frequently swapped out.

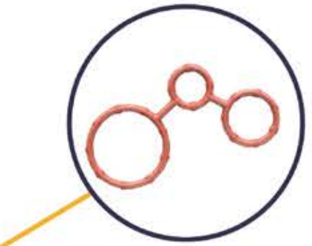
These seals are critical for maintaining the efficiency and reliability of liquid cooling systems in data centers, ensuring that the cooling fluid remains contained and the system operates effectively, but not all seals are made the same.

DATA CENTER SEALING SOLUTIONS



Custom Molded Seals

A custom-designed enclosure seal can be designed to provide a seal to meet challenging grooves and closure force requirements.



Press-in-Place Seals (PIP)

Press-in-Place (PIP) Seals are a great homogeneous rubber option to seal a complex groove path with very little room for a groove.

Lathe Cuts

Advanced cutting technologies can provide seals in a wide variety of cross-sections and wall thickness combinations to meet design challenges.

O-Rings

Standard O-rings with innovative materials can be provided for critical chemistries.

Cure-in-Place Gaskets (CIPG)

For a more automated solution, Cure-in-Place Gaskets (CIPG) can be used for efficiency in manufacturing.

Extruded and Spliced Seals

Large perimeter extruded seals provide a simple and reliable means of customizing a seal for specific battery housing while reducing tooling cost and minimizing closure force. Optimal seals include Parker's hollow keyhole, jigsaw, and hexapod profiles.

Material Compatibility and Reliability

Proper material testing is essential for ensuring the reliability and safety of seals in sensitive environments. For seals, fluid immersion tests, where materials are exposed to specific fluids at a given temperature and physical properties are measured before and after, help predict material behavior in different environments.

1. **Volume Change:** This evaluates the swelling or shrinkage of the seal material. Volume change is a critical indicator of fluid compatibility, as excessive swelling or shrinkage can lead to seal failure. In addition, Volume change in a material indicates extraction liquid ingredients (plasticizers) from the rubber seal or absorption of the cooling medium into the rubber seal. Both are problematic. In the case of long-term exposure, the extraction of plasticizers can contaminate the coolant and increase its conductivity.
2. **Compression Set:** This measures the material's ability to return to its original thickness after being compressed. A high compression set indicates that the material may not recover well, leading to potential leaks
3. **Visual:** Visual inspection for changes such as cracking, discoloration, or surface degradation provides additional insights into the material's condition
4. Other physical properties measured pending application requirements are hardness, tensile strength, and elongation at break. Changes in any of these three properties can indicate degradation or weakening of the material.

IRM 901 oil (and the older ASTM #1 oil) is the relevant standard test fluid for evaluating seal compatibility with hydrocarbon-based dielectric/heat transfer fluids. In general, a small amount (1-2%) of shrinkage or swell (up to about 10%) is acceptable. Below shows how various seal materials generally perform per IRM 901. For water/glycol coolants, these recommendations are reversed.

However, volume swell is not a good indicator of long-term performance. The damage in hot water/glycol coolants is cracking, hardening, and accelerated compression set. Unfortunately, testing for these failure modes is often overlooked when determining the appropriate sealing solution.

Material selection is critical in proposing the integrity, functionality and safety in various thermal management systems, but material selection is only the first step. Proper design and engineering support are critical in making sure that seals perform as intentioned. The following case studies demonstrate where the right material, design, and implementation were needed to come together to create the right solution for each customer.

IRM 901 Oil Immersion Testing

Material Type	IRM 901 Vol Change	Rating	When to use in these oils	Temp Range
NBR	-2%	Excellent	1st choice	-25 to +275°F
HNBR	+2%	Excellent	Higher temp application	-25 to +300°F
Low temp NBR	-10%	Not Recommended	Not Recommended	-50 to +212°F
EPDM	>100%	Not Recommended	Not Recommended	N/A
Neoprene	+8.5%	Fair	Not Recommended	-35 to +225°F
FKM	+1%	Excellent	Extreme high temp performance	-15 to +400°F
Fluorosilicone	+3%	Excellent	Extreme low temp performance	-100 to +350°F

Water/Glycol Immersion Testing

Material Type	Damage	Rating	When to use in these oils	Temp Range
NBR	Compression set, hardening	Fair	When max temp <120°F	-25 to +275°F
HNBR	Minimal	Good	When both oil and water resistance are needed	-25 to +300°F
Low temp NBR	Cracking, hardening	Fair	Not Recommended	-50 to +212°F
EPDM	None	Excellent	1st Choice	-70 to +250°F
Neoprene	Compression set	Fair	Not Recommended	-35 to +225°F

CASE STUDIES

LIQUID COOLING TECHNOLOGY COMPANY

COMPANY BACKGROUND	CHALLENGE	SOLUTION	BENEFITS
Designer and OEM of Liquid cooling systems	Needed an alternative to barb fittings and hoses, chemical/fluid compatibility issues and fittings were leaking.	Installed a stainless-steel coupling system that connects the liquid and gas circuit	Extended life with leak-free stainless steel components, eliminated compatibility issues and enhanced serviceability/ ease of installation

CLOUD COMPUTING COMPANY

COMPANY BACKGROUND	CHALLENGE	SOLUTION	BENEFITS
Designer and manufacturer of their own liquid cooling systems throughout multiple locations	The use of tap water caused coupling systems to fail due to contamination & corrosion Needed a cost-conscious, readily available solution	Switched to plastic fittings for enhanced material compatibility and cost savings	Extended service life and enhanced reliability Reduced downtime with locally sourced products

DIRECT-TO-CHIP COOLING PLATE MANUFACTURER

COMPANY BACKGROUND	CHALLENGE	SOLUTION	BENEFITS
Designer and manufacturer of liquid cooled data center components	Company was moving from a welded cooling plate design to a compression system that relied on seals. Initial seals sourced were starting to fail after a few months of use.	Switched seal material for enhanced material compatibility as well as created custom molded seals to for specific requirements	Switch to a compression fastening system allowed for accessibility for rework and maintenance Lower manufacturing cost and reduced scrap versus welding

Closing

Regardless of the liquid cooling methodology—whether it's direct-to-chip, immersion, single-phase, or two-phase cooling—or the implementation strategy, be it full conversion or a hybrid system, reliable sealing solutions are indispensable. The success of these cooling systems hinges on the design, material selection, reliability, and integration support of the seals used. These factors ensure that the cooling fluid remains contained, preventing leaks and maintaining system efficiency. By prioritizing high-quality sealing solutions, data centers can achieve optimal performance and longevity, safeguarding their critical operations.

At Parker Hannifin, we pride ourselves in having a globally trusted name for quality and reliability. Our global network of engineers and commercial teams can offer one-stop service for your local sealing solution requirements.

SEALING SOLUTIONS FOR LIQUID COOLING

One stop service

DESIGN & DEVELOPMENT
- Part, Material
- Elastomer Formulation & Engineering

MATERIAL COMPOUNDING
- Material auto batching
- Dedicated compounding mill

TOOLING
- Design
- High speed CNC
- EDM
- Wire cut

PRECISION MOLDING
- Compression/ Transfer
- Injection (LSR)
- Insert/ Over mold

SECONDARY PROCESS
- Post curing
- Deflashing
- Coating/ Surface treatment
- Light assembly

TESTING: Chemical & Mechanical (ISO 17025 certified)

READY TO BUY?

Contact Parker Hannifin for support to design and develop sealing solution that meet your business and site requirements.

APPENDIX

Material Type	Product Type	Temperature	Color
Acrylonitrile-Butadiene (NBR)			
N0674-70	O-Rings and extruded seals	-30 to 250°F	Black
NA103-70	Press-in-place (PIP) and custom molded seals	-30 to 225°F	Black
N0951-75	O-Rings (improved compression set vs. N0674-70)	-25 to 275°F°F	Black
Hydrogenated Nitrile (HNBR)			
KB161-70	O-Rings, extruded seals, pressi-in-place (PIP), and custom seals	-25 to 300/325°F	Black
KA158-70	O-Rings (improved low temperature vs. KB161-70)	-40 to 300°F	Black
Ethylene Propylene (EPDM)			
E0667-70	O-Rings, press-in-place (PIP) and custom molded seals	-70 to 250°F	Black
E7736-70	Extruded seals	-70 to 250°F	Black
Fluorocarbon (FKM)			
VM330-75	O-Rings, extruded seals, press-in-place (PIP) and custom molded seals	-15 to 400°F	Black
VW076-75	O-Rings, extruded seals	-15 to 400°F	Brown
VW340-75	Press-in-place (PIP) and custom molded seals	-15 to 400°F	Brown
Fluorosilicone (FVMQ)			
LM100-70	O-Rings	-100 to 350°F	Black
LM256-70	Press-in-place (PIP) and custom molded seals	-100 to 350°F	Black
L7232-70	Extruded seals	-100 to 350°F	Black

Resources:

1. Data Center Cooling Best Practices. (2023). Datacenters.com. Retrieved August 5, 2024, from DataCenters.com
2. Cunningham, E. (2020, May 6). Liquid cooling can transform High-Density state and local government data centers. Technology Solutions That Drive Government. StateTech Magazine.
3. Korolov, M. (2024, June 3). Five barriers to adoption of liquid cooling in data centers. From DataCenterKnowledge.com

Parker Hannifin Corporation
EMG/O-Ring & Engineered Seals Division
2360 Palumbo Drive
Lexington, KY 40509
phone 859 269 2351
www.parker.com/oes

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